Distribution of Gillnets and Spring Spawning Grounds of Atlantic Herring in the Southern Gulf of St. Lawrence as Inferred from Aerial Surveys

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DISTRIBUTION OF GILLNETS AND SPRING SPAWNING GROUNDS OF ATLANTIC HERRING IN THE SOUTHERN GULF OF ST LAWRENCE AS INFERRED FROM AERIAL SURVEYS

by:

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ABSTRACT

Messieh, S.N., and R.A. Pottle. 1986. Distribution of gillnets and spring spawning grounds of Atlantic herring in the southern Gulf of St. Lawrence as inferred from aerial surveys. Can. Tech. Rep. Fish. Aquat. Sci., No. 1504, viii + 53 p.

The density and distribution of herring gillnets deployed during the inshore spring herring fishery in the southern Gulf of St. Lawrence were determined by aerial surveys in 1980, 1981 and 1983. Strings of fixed gillnets were easily identified on photographs which has a ground scale of 1/6000 ± 5%.

Composite photographs of the surveyed areas were used to determine the total number of standard gillnets deployed and the distribution per square kilometer within the areas surveyed. Each area included in the surveys was photographed 4-7 times per fishing season. Algal cover on substrate was recorded and used along with gillnet distribution to identify the herring spawning locations. Results agreed with information collected by questionnaires and interviews with fishery officers and experienced fishermen.

Aerial photographic surveys provide a means of assessing fishing effort, in terms of number and size of gear deployed, which is relatively easier and more cost effective than most conventional methods. Aerial surveys are suitable for quantification of effort in fisheries such as spring herring fisheries in the Gulf, in which many small vessels are involved, with wide distribution of gear and considerable day to day variation in amount of gear deployed, provided that the net height and mesh size are constant or that the distribution of these parameters is known.

RESUMÉ

Messieh, S.N., and R.A. Pottle. 1986. Distribution of gillnets and spring spawning grounds of Atlantic herring in the southern Gulf of St. Lawrence as inferred from aerial surveys. Can. Tec. Rep. Fish. Aquat. Sci., No. 1504; viii + 53 p.

Des relevés aériens menés en 1980, 1981 et 1983 ont servi à déterminer la densité et la distribution des filets maillants à hareng déployés durant la saison de pêche printannière de cette espèce dans les régions côtières du golfe du Saint-Laurent. Les trains de filets maillants sont facilement identifiables sur des photographies à échelle de 1/6000 ± 5% au sol.

Pour déterminer le nombre total et la distribution des filets standard tendus, pr kilomètre, dans les zones couvertes, on a utilisé des photos composites de ces zones. Chacune a été photographiée entre 4 et 7 fois par saison de pêche. La couverture algale de substrat a été notée et on l'a utilisée, conjointement avec la répartition des filets maillants, pour identifier les frayères de hareng. Les résultats s'accordent avec les renseignements obtenus à l'aide de questionnaires et avec les interviews d'agents des pêches et de pêcheurs expérimentés.

Les relevés par photographie aérienne permettent d'évaluer l'effort de pêche en termes de nombre et de taille des engins utilisés; ils sont relativement plus faciles d'exécution et donnent un meilleur rendement par rapport aux coûts que la plupart des méthodes conventionnelles. Ces relevés permettent de plus de quantifier l'effort dans des pêcheries telles que celles du hareng de printemps dans le Golfe, auxquelles s'adonnent plusieurs bateaux de faible tonnage, avec éparpillement des engins et fortes variations journalières des quantités de filets tendus, pourvu que la hauteur des filets et la dimension des mailles soient constantes, ou encore que soit connue la répartition de ces paramètres.

INTRODUCTION

The spring inshore herring fisheries in the southern Gulf of St. Lawrence are directed towards fish which have migrated into relatively shallow water to spawn. The spring spawning areas are usually within 1 km of shore at depths of less than 6.0 m (Tibbo et al., 1963; Pottle et al., 1981; Messieh et al. 1985), and fishermen tend to set their nets within or on the approaches to these areas.

Although catch statistics for the inshore herring fisheries in the southern Gulf of St. Lawrence are available back to 1933 (Tibbo et al., 1969), fishing effort and catch per unit effort (CPUE) are only available since 1973 (Messieh, 1984). Estimates of fishing effort and CPUE are based on analysis of purchase slip data.

Purchase slip data provide information on the total number of fishing trips and catch per trip. Because of the large number of vessels involved in the widely dispersed inshore herring fisheries, and the absence of logbooks, fishing effort data in terms of number of nets fished in each trip is lacking. Until 1979 only rough estimates of the number of nets used, based on questionnaires and interviews with fishermen, were available. The number of responses from fishermen was generally low and the data collected were later found to greatly underestimate the amount of fishing gear deployed. Many fishermen were thought to be reluctant to provide accurate data on number of nets used, due to the fear of future regulations and limiting their fishing activities.

The number and distribution of gillnets were monitored in Miramichi Bay in May 1979 by aerial survey. This method of quantifying fishing effort in terms of number of gillnets deployed appeared promising, and aerial photographic surveys of six major spring spawning areas were conducted in 1980, 1981 and 1983.

Besides herring gillnet distribution, the aerial photographic surveys also showed the algal cover on substrate. Several studies of herring spawning beds have indicated a positive correlation between intensity of egg deposition and degree of algal cover on the substrate (Haegle et al.,1979; Pottle et al., 1981; Tibbo et al., 1963). It was felt that mapping of algal cover aerial photographs would indicate potential spawning site locations.

It should be noted, that photography was confined to those districts which supported a commercial fishery, and within these districts expanses of coastline without nets were not usually photographed. It has been assumed that fishermen, through past experience, have learned the locations of major spawning areas in their districts and therefore, that major concentrations of set gillnets are likely to be on or near herring spawning beds.

Information on spawning grounds as inferred from aerial surveys was compared with historical data reported by Leim (MS 1956) which were based on fishermen interviews in the late 1940's, with a report by

Ware and Henriksen (1978) based on catch statistics, and from questionnaires distributed by the authors to district fishery officers during the 1980 fishery.

MATERIALS AND METHODS

A single engine PA-22 150 Piper tri-pacer was chartered for the 1979 pilot study and for the 1980 survey. The aircraft was equipped with a K17B aerial camera with 6" focal length and a yellow filter (minus blue). The camera mount was adjustable for tilt and drift angle, and Tri-X aerographic 2403, Estar base, 10" format film was used.

A twin engine PA-23 250 Piper aircraft was chartered for the 1981 and 1983 surveys. It was equipped with a Wild RCB aerial camera with a 6" focal length and a yellow, anti-vignetting filter. Double-X Kodak 2406, Estar base, 10" format film was used.

During the 1979 pilot study photographs were taken at altitudes of 3000 and 6000 ft. Those taken at the lower altitude (scale 1/6000) were more suitable for the identificaiton and measurements of herring gillnets, and all subsequent surveys were made from this altitude. Variations in the scale of the photographs due to minor fluctuations in altitude were within a range of $\pm$ 5%. Scale was checked using landmarks of known dimensions (ie. distance between navigation range lights).

The photographs taken on each transect had a planned overlap with each other and with the photographs on adjacent transects. The problem of sun glare refected from the water was largely overcome by making the survey flights near midday.

The gillnets used in the spring fishery are 90 ft. (27.4 m) long and 12 ft. (3.7 m) deep. These are set in strings of up to six nets, anchored at each end and roughly parallel to shore. Most strings are one net (3.7 m) deep; however, a small number of those set further offshore are two nets deep. The latter tend to be used in the early phase of the fishery, when schools of herring which have not begun to spawn are detected by echosounder in deeper water. The head of each gillnet is supported by evenly spaced floats which, together with the anchor line buoys at each end of the string, are clearly visible in the aerial photographs (Figure 1) and distinguish gillnets from lobster gear set in the same area. (Figure 2) shows the fishery districts in the southern Gulf of St. Lawrence.

Gillnets in the aerial photographs were identified with a large stage, binocular microscope at 6.4X magnification, and carefully high-lighted with a wax pencil. Matt prints of the photographs were preferred because the reflection from glossy prints interfered with net identification under the microscope. Mapping of net distribution was accomplished by fitting photographs taken during a survey flight together to form a composite of the area surveyed. This was facilitated by the overlap of photographs taken on adjacent transects, by shore landmarks, and by the sequential numbering of photographs on the flight path charts. Composite photographs were not assembled for areas in which net distribution was sparse.

Transparent acrylic sheets were laid over the composite photographs (the largest of which measured approximately 2.7 x 1.2 m) and the gillnets and shoreline were carefully traced on the transparency with a fine tipped, indelible ink, felt pen (Figure 3). Net tracings on the transparencies were measured to the nearest 0.1 cm by two methods in 1980; by digitizer, a computer-linked tracing board which recorded the lengths of objects traced with a cursor, and by opsciometer, a map measurement gauge. The difference between mean measurements obtained by these methods was not significant, and subsequent measurements in 1981 and 1983 were made by opsciometers alone. Measurements were converted to number of standard gillnets in use per day per survey area. A 1 km^2 grid was superimposed on maps of the coastline and the lengths of all strings of nets within a grid square were measured. With these lengths the number of standard length gillnets/km^2 was determined.

Six areas believed to support the largest inshore spring herring fisheries were selected for the aerial surveys. These were the Caraquet, Neguac, Escuminac, Kouchibouguac, and Shediac areas in NB, and North Point, PEI (Figure 4). The small fisheries in southern PEI and in Georges Bay, NS were not surveyed. Each area was photographed 4-5 times between May 4 and 31 in 1980, 5-6 times between April 28 and June 2 in 1981, and 4-7 times between April 28 and June 3 in 1983. The start and end of the fishery were monitored by search flights scanning the area, before the aerial photographs were taken.

Algal cover was designated as either sparse, moderate or heavy and was estimated from photographs visually using the following guidelines:

Low: <50% coverage within zone occupied by algae
Moderate: 50% - 75% coverage within zone occupied by algae
Heavy: >75% coverage within zone occupied by algae

Where possible, estimates were made from several photographs of an area, taken on different days and at different times to eliminate the masking effect of glare and turbidity.

Information on spawning grounds as inferred from aerial surveys was compared with historical data reported by Leim (MS 1956). These data were based on fishermen interviews in the late 1940's. Comparison was also made with data reported by Ware and Henriksen (1978) based on catch statistics, and from questionnaires distributed by the authors to district fishery officers during the 1980 fishery.

RESULTS

I. GILLNET DISTRIBUTION

Fishing effort estimates for spring herring fisheries in the southern Gulf of St. Lawrence, separated by fishery and year are presented in Table 1. Fishing effort is expressed in terms of average numbers of standard nets fished during the fishing season. This is

calculated from the average number of nets fished per day multiplied by the number of actual fishing days during the fishery. Fishing effort shows Escuminac to be the most significant spring fishery in the Southern Gulf (Table 1). Shediac was the most variable having a three fold range of effort level. Caraquet and North PEI were about the same. Kouchibouguac on average - had the lowest fishing effort during the 3 years of observation.

A detailed break-down of fishing effort by Fishery District and survey flight is contained in Tables 2-4. The mean number and corresponding length in kilometers of gillnets counted per survey flight for the three years of investigation are shown. The basic measurement of fishing effort was the number of standard nets fished per day, where a standard net was 27.4 m long.

Gillnet distribution in number of standard nets per square kilometer was plotted for each survey flight and is described below for each survey area.

Caraquet Area

Survey flights in this area covered approximately 60 km of coast from Belloni Pt. (District 64) to Point des Blanchard (District 66). In 1980 major concentrations of nets were observed in the Belloni Point - Janeville area and at Blue Cove with a minor concentration of nets at Caraquet Island (Figure 7). In terms of fishing effort, the Caraquet region had dropped from second to third place among the areas surveyed between 1980 and 1983.

Neguac Area

The Neguac fishery was the smallest, in terms of fishing effort, of the six fishery areas surveyed. Gillnets were usually set in an area of 2 km^2 on the south side of Hay Island, with a maximum observed concentration of 76 - 100 standard nets per square kilometer (Figures 8,9). In 1983, the concentration of nets did not exceed 25 standard net per square kilometer (Figure 12).

Escuminac Area

This area on the south of Miramichi Bay supports the largest spring herring fishery in the southern Gulf of St. Lawrence. Gillnets were usually set along 15 km of shoreline between Fox Island and Point Escuminac, and up to 4 km from shore. In all three years of the aerial survey, the maximum concentrations of nets exceeding 100 standard gillnets/km^2 were located within the historical shallow water spawning area between Preston Beach and the Escuminac wharf.

In 1980, there appeared to be a shift of fishing gear approximately 1 km towards the shore into the spawning area between May 4 and May 17 (Figure 10). In 1981 and 1983 the gillnets were concentrated within the spawning area for the duration of the fishery (Figures 11,12). A marked

eastward extension of the area of maximum effort occurred in May 20-21, 1983 (Figure 12). The herring had spawned east of Escuminac wharf on May 19-20 and the shift of fishing gear was in response to the large catch that night. A large spawning bed was located and surveyed by divers along the inner edge of the new concentration of gillnets.

In all aerial surveys, the fishing effort in the Escuminac area exceeded that of all other surveyed areas combined. In 1981 and 1983 a moderate amount of fishing effort was noted in Bay du Vin, on the southwest shore of Inner Miramichi Bay (Figures 11, 12).

Kouchibouguac Area

The Kouchibouguac area supported the second smallest of the surveyed fisheries. gillnet distribution was uneven along the 40 km of coast surveyed, and concentrations per square kilometer were low in most of the areas fished. Fishing effort was concentrated in District 76, between Richibucto Cape and Dune de Buctouche in 1980 and 1981 (Figures 13, 14). In 1983 there was a substantial increase in effort north of Richibucto Cape, particularly near North Kouchibouguac. Variation in amount and location of gear deployed during the fishing season is well illustrated by Figure 15.

Shediac Area

In terms of effort the Shediac area supported the fourth largest inshore herring fishery in the Gulf in 1980, and the second largest in 1981 and 1983. In 1980, 62.3% of the fishing effort was concentrated in District 77 between Dixon Point and Pointe aux Rénards, with an irregular distribution of nets between Shediac and Fagan Point in District 78 (Figure 16). In 1981, 70.9% of the fishing gear was set in District 77, and the area of concentration had extended southward from Point aux Rénards to Grand Digue (Figure 17).

Most of the fishing gear was set in District 77 in 1983 although there was increased effort in the Cap Pelé-Fagan Point area of District 78 and a substantial number of nets were set briefly between Fagan Point and Johnson Point (in District 80) on may 16 (Figure 18).

North Point, PEI

The North Point area supports the largest spring herring fishery in PEI. However, in terms of fishing effort it has declined from the third largest of the areas surveyed in 1980 to the fifth largest in 1983. Nets were found on both sides of North Point in 1980, with the majority on the northeast shore (Figure 19). In 1981 and 1983 all fishing effort appeared to be concentrated along the northeast shore and directly off-shore from North Point (Figures 20, 21).

II. SPAWNING GROUNDS

Caraquet Area

District: 65

Historically, this was an area of high intensity spawning where vast quantities of eggs were occasionally washed ashore after storms (Prince, 1907). Leim (MS 1956), after interviews with local fishermen and fisheries officers, stated that the catch was evenly distributed along the shore of the district and commented on the large amounts of spawn washed ashore by spring storms. Nets were set 0.4 - 0.8 km offshore in spring, on Caraquet Bank and at some onshore locations in the fall.

Ware and Henriksen (1978) mention an historical spring spawning site near Grand Anse with contemporary spring sites at Grindstone Pt., and in Baie de Caraquet, and a fall site at Caraquet Is. Replies to our spring 1980 questionnaire (Messieh et al., unpublished) again mentioned that large quantities of spawn occasionally washed ashore prior to 1967. Both spring and fall sites were said to be found at Cranberry Cape, Grand Anse and near both ends of Caraquet Island. Aerial photographs, however, showed very few nets in the Grand Anse and Caraquet Island areas. The major concentrations in May, 1980 were at Salmon Beach, Janeville (just south of Cranberry Cape), Grindstone Point and Blue Cove with concentrations of up to 188 nets/km^2 in the last location. All of these areas had medium to heavy algae cover. Although there was medium to heavy cover at Point de maisonettes and the northwest end of Caraquet Island, there were few nets in these locations.

It appears that Caraquet Bay and Grand Anse are no longer major spring spawning sites and that the major concentrations of spawners are now found farther west between Blue Cove and Salmon Beach, within 1 km of shore (Figure 22).

District: 66

The most recent data for this district was compiled by Ware and Henriksen (1978). Aerial photographs were not taken in this area and no response to the 1980 questionnaire was received. Leim (MS 1956) stated that spring spawners were evenly distributed around the Miscou and Shippegan Islands within 1.2 km of shore. Fall herring were caught along the northern sides of the islands from Caraquet to Miscou Pt. in 5-8 fathoms (9-15 m), 2.4 - 3.2 km from shore. According to Ware and Henriksen (1978) spring sites have been located on the northern side of Shippegan Island in recent years and fall sites are found at the north end of Miscou Island and on the south side of Shippegan Island. Spring catches in the Caraquet/Shippegan area have declined markedly since 1968 (Messieh and Moore, 1981).

District: 68

Ware and Henriksen (1978) do not mention any major spawning sites in this area. Our questionnaire data indicate a very small fishery in the district with minor spawning sites at Green Pt. and Val-Comeau. There are no records of fall spawning herring in the area. In the past, spawning was problably more intense as Leim (MS 1956) stated that herring eggs were "sometimes cast up on the shore in quantity". He also stated that nets were set as close to shore as possible, generally within 200 m, as the fishermen "used to miss the run by fishing too far offshore". We have no data on the 1980 net and algae bed distributions in district 68.

Neguac Area

As in district 68 there are no fall spawners in the area, and no major spawning sites (Ware and Henriksen, 1978). According to Leim (MS 1956) the spring catch was taken primarily between Neguac and Burnt Church (inside fishing) although some fish were caught outside the barrier islands off Tabusintac. Nets were set no further than 0.4 km offshore nor at depths greater than 6 m. The fisheries officer's reply to our 1980 questionnaire placed the spawning sites between Rocky Pt. and Hay Is., and on the northwest side of Portage Island, with the major fishing effort in the same locations and additional fishing just outside and flanking Old Tabusintac Gully.

Aerial photographs showed moderate to heavy concentrations of algae at Burnt Church and along the southern shore of Hay Is. There were a few gillnets scattered south of Burnt Church and Hay Is. but these were just outside of the algae beds (Figure 23).

Escuminac Area

District: 73

According to Leim (MS 1956) spring spawners were formerly "equally abundant" from Bay du Vin to Pt. Sapin (District 75) and were caught from 45 m to 0.8 km offshore in 3-4 m of water. Fall spawners were caught further offshore and never west of Escuminac settlement. Large amounts of spawn were occasionally washed ashore in spring, but never in fall.

More recently, Ware and Henrikson (1978) indicated that major spring spawning sites were located in Bay du Vin and from Preston Beach to the south side of Pt. Escuminac. They also mentioned an historical fall spawning area from Escuminac to Pt. Escuminac, located further offshore than the spring spawning zone. These data are essentially identical to that obtained from our 1980 questionnaire. The 1980 fishing effort was concentrated between Fox Island and the government wharf at Escuminac, within 2 km of shore.

The heaviest algal cover was off Huckleberry Island in the same location as the only spawning bed located during our May 1980 survey (Pottle et al., 1981). Algal cover was moderate to heavy from Preston Beach to the western edge of Herring Cove, approximately 3 km west of Pt. Escuminac (Figure 23).

District: 75

According to Ware and Henriksen (1978) the historical spring spawning site extended south from Cape Sapin to the barrier islands outside of Kouchibouguac Lagoon, and fall spawning did not occur in the area. Leim (MS 1956) mentioned that there was some fishing effort outside of the barrier islands north of Richibucto (within 0.4 km of shore) and mentioned the occurrence of fall spawners, but failed to pinpoint the locations of fall spawning sites. These sites may have been in either of Districts 75 or 76 as he did not distinguish between them.

In reply to the 1980 questionnaire the local fisheries officer stated that there was heavy spawning on the southern side of Point Escuminac, and light spawning from South Cape to North Kouchibouguac Lagoon in both spring and fall, with the fishing effort spread over the entire area (Figures 23, 24).

Kouchibouguac Area

District: 76

Both spring and fall fisheries were formerly concentrated at Richibucto Head and Richibucto Harbour, generally within 0.4 km of shore (Leim, MS 1956). In more recent years there has been a fall spawning site at Richibucto Head but there are no longer spring sites in the district (Ware and Henriksen, 1978). In May, 1980, the district fisheries officer stated that the region was "not known as a spawning area for the last few years". A light fishing effort is, however, still maintained at Cote Ste. Anne and North Richibucto Beach in spring and near Richibucto Head in fall.

Coverage of the shoreline by aerial photography was very sparse. However, low to medium concentrations of algae were detected along Richibucto Head and close to Cote St. Anne (Figure 24).

District: 77

Formerly, spring and fall spawners were caught all along the shore outside of Buctouche Bay from 400 m to 8 km offshore, depending upon the season (Leim, MS 1956). Leim stated that spawn was sometimes washed ashore in large quantities. Ware and Henriksen (1978) stated that major spring or fall spawning sites were no longer found in the district.

According to the 1980 questionnaire spawning still occurs in both spring and fall, with sites located between Baie de Cocagne and Pointe aux Renards, and at Cap de Caissie. An additional fall site is located

south of St. Edouard de Kent on the peninsula outside Buctouche Bay. The fishing effort was said to be concentrated between Bar de Cocagne and Cap de Cocagne in both spring and fall, with additional fall fishing at St. Edouard de Kent and St. Thomas de Kent. However, aerial photos (spring 1980) revealed major concentrations of nets between St. Thomas de Kent and The Bluff, at Cocagne Is. (east side), and from Pointe aux Renards to Cap de Cocagne. The first two of these concentrations coincided with the areas of heaviest algal cover in the district (Figure 24).

Shediac Area

District: 78

There have been reports on spring spawning population of herring in this district since at least the early 1940's. At that time the spring spawning area extended from Cap Bimet to Shemoque R., with the major concentration of fish within 0.8 km of shore between Cap Bimet and Cap Bauld. Very few herring were caught in Shediac Bay.

Ware and Henriksen (1978) stated that the major spring spawning site was on the eastern side of Shediac Island, and that the spring sites had formerly been between Cap Brule and Cap Bimet, and between Cap Pele and Fagan Pt.

From both the questionnaire and aerial photographs, it appears that the spring spawners had returned to the historical sites in 1980. Major concentrations of nets were found between Cap Brule and Cap Bimet, at Pte. aux Bouleaux, and near Bas Cap Pele (Figure 25).

District: 80

This district does not seem to have supported a large fishery in many years. Leim (MS 1956) stated that no fish were caught from Cape Tormentine to the Nova Scotia border. Ware and Henriksen (1978) stated that there were no major spawning sites in the district. Questionnaire data indicate the presence of four spring spawning sites at Petit Cap, Cadman Pt., offshore of Peacock Cove, and Cape Tormentine; however, these are assumed to be small. The main 1980 fishing effort was expended between Petit Cap and Cape Tormentine, with a few nets in Baie Verte. There are no fall spawners in this district.

Aerial photographs showed very few nets (5 nets) in this district near Johnson Point in May, 1980. Algal distribution ranged between low and medium (Figure 25).

North Point, PEI Area

District: 82

Leim (MS 1956) did not discuss the fishery in this area. Ware and Henriksen (1978) indicated fall spawning sites from North Point southwest

of Norway, PEI. Responses to the 1980 questionnaire placed spring spawning sites at depths of 2-6 m from Miminegash to Nail Head, and fall sites at 9 m depth between West Pt. and Seal Pt. and offshore from Nail Head to North Pt. at a depth of 20 m. Spring fishing is usually conducted between West Pt. and North Pt., whereas the fall fishery is concentrated around Nail Head. Aerial photographs revealed very few nets (max. 14 nets/km^2) in this area in May, 1980. These were located between Norway and North Point. Although photo coverage was incomplete, moderate algal cover was detected from North Pt. south about 1/3 of the distance to Nail Head (Figure 26).

District: 92

Ware and Henriksen (1978) indicated that there was no spring spawning in this district, although spawning occurred off North Pt. in the fall. The questionnaire results indicated both spring and fall spawning sites at North Pt. with a further spring site between Cape Kildare and Alberton. Spring fishing is usually from North Pt. to Cavendish Inlet, with fall fishing only off North Pt.

Aerial photos revealed a concentration of gillnets between North Pt. and Seacow Pond, with very few (<50 nets/km^2) nets further south. Algal cover was moderate from Seacow Pond to North Pt. and moderate to heavy north and northeast of the point(Figure 26).

DISCUSSION

The major inshore spring herring fisheries in the southern Gulf of St. Lawrence during 1980-83 were located in Districts 65, 73, and 78, all of which have been important historically. Spring spawning locations have varied somewhat in districts 65 and 78. In the former, the fishery has shifted westward from the Caraquet area to the Belloni Pt. - Grindstone region with another major fishing site at Blue Cove. In Distict 78 the 1980 spring spawners returned to the historical spawning sites between Cap Bimet and Fagan Pt., having spawned in the Shediac Island area for some years (Ware and Henriksen, 1978). The Miramichi Bay spawning grounds do not appear to have changed for at least 50 years, and support the largest inshore herring fishery in the Gulf.

Aerial photographic surveys provide a method of assessing effort in the inshore herring fisheries of the southern Gulf of St. Lawrence which is relatively easy, time saving, and more cost effective than conventional methods. In this fishery the quantification of fishing effort by other means, such as purchase slips, is difficult due to the large number of vessels involved, wide distribution of gear, and the variation of effort with time. In 1984, estimation of fishing effort by the purchase slip method was not possible because fishing was restricted to a bait fishery and hence no purchase slips were available.

Aerial surveys have shown that fishing effort within a particular area can vary considerably in density and location over a period of a few days. Such variation is to be expected because fishermen alter the number of gillnets in use and their locations on an almost daily basis, in response to the quantity and distribution of the local catch.

In all areas surveyed, there are specific sites in which fishing effort is concentrated from year to year, although a shift of gear distribution was noted in the Shediac region in 1983. These concentrations of gear are believed to coincide in location with the major herring spawning beds in each area.

Total observed fishing effort in terms of number of gillnets observed in a single flight ranged from a low of 3 standard nets at Neguac to a maximum of 3361 at Escuminac in 1981. The magnitude of the fishing effort in the latter area can be more easily appreciated in view of the small area (<15 km^2) in which more than one half of the gillnets were set. Observed concentrations of 155 standard gillnets per square kilometer within a known shallow spawning site at Escuminac constitute a formidable obstacle to schools of spawning herring. Recent data have indicated an alarmingly high exploitation rate in this fishery , the largest of the inshore spring herring fisheries in the Gulf (Messieh et al. 1985). If the decision is made to regulate fishing effort on known spawning sites, aerial photographic surveys can be used to monitor the quantity of fishing gear in restricted areas.

There are some limitations to the accuracy of aerial photographic surveys. The quality of the photographs and thus the number of gillnets visible depends upon the skill of the pilot and photographer, meteorological conditions, and the limits of resolution of the photographic equipment. Other problems are associated with the fishing gear itself, particularly the presence in deeper water of strings of gillnets more than one standard net deep, and "sunken nets" whose headline floats are submerged due to either design or a large number of fish in the net.

Aerial surveys have been used in the Pacific herring fishery since the 1950's, although the early surveys were of a qualitative nature only (Haegele and Hamey MS 1976). These surveys are now considered the most practical and cost effective means of assessing spawning populations of Pacific herring. Aerial surveys have been also recommended by the Food and Agriculture Organization of the United Nations (FAO) for monitoring fishing effort particularly in the artisanal fisheries when fishing activity is distributed over a vast area and when fishermen operate from remote small fishing communities (Bazigos, 1975; Banerji 1974).

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Table 1: Fishing effort of spring inshore herring gillnet fisheries during 1980-83*. Data from aerial surveys of five areas of the southern Gulf of St. Lawrence.

Fishery	Number of standard nets** X days fished during fishing season		
	1980	1981	1983
Caraquet	10,864	10,824	6,143
Escuminac	49,770	70,200	37,263
Kouchibouguac	4,600	8,580	5,724
Shediac	7,540	21,714	10,086
North PEI	8,980	9,480	5,687
Total	81,754	120,798	64,903

* No aerial survey in 1982
** A standard net/day is one 27.4 m (90 ft) net fished for 24 hour period.

Table 2: Number and length of herring gillnets along the southern coast of Gulf of St. Lawrence during May, 1980 aerial surveys

Location	Fishery District	Date	Number of Standard Nets	Length of Nets (km)
Caraquet Area				
Belloni Pt. - Janeville	64-65	May 15	523	14.330
		May 22	185	5.069
		May 31	489	13.399
Janeville - Grande Anse	65	May 17	145	3.973
		May 22	53	1.452
		May 31	137	3.754
Blue Cove	65	May 17	385	10.302
		May 22	363	9.946
		May 31	376	10.302
Maisonette - Pt. Blanchard	65	May 22	47	1.288
		May 31	11	.301
Neguac Area	70	May 15	149	4.083
		May 20	128	3.507
		May 23	104	2.850
		May 31	10	.274
Escuminac Area	73-75	May 4	2,252	61.705
		May 17	2,092	57.321
		May 22	814	22.304
		May 28	747	20.468
		May 31	715	19.591
Kouchibouguac Area	75	May 11	35	.959
		May 20	49	1.343
		May 23	28	.767
		May 28	49	1.342
		May 31	9	.247
	76	May 11	105	2.877
		May 20	172	4.713
		May 23	390	10.686
		May 28	164	4.494
		May 31	76	2.082
	77	May 23	24	.658
		May 28	47	1.288

(CONT'D)

Table 2 (continued)

Location	Fishery District	Date	Number of Standard Nets	Length of Nets (km)
Shediac Area	77	May 18	380	10.412
		May 23	362	9.919
		May 28	505	13.837
		May 31	74	2.028
	78	May 11	204	5.590
		May 18	320	8.768
		May 23	120	3.288
		May 28	158	4.329
		May 31	42	1.151
	80	May 18	20	.548
North PEI	82	May 11	22	.603
		May 18	71	1.945
		May 23	29	.795
		May 31	69	1.891
	92	May 11	700	19.180
		May 18	336	9.261
		May 23	332	9.097
		May 31	234	6.412

Table 3: Number and Length of herring gillnets along the southern coast of the Gulf of St. Lawrence, spring 1981 aerial surveys.

Location	Fishery District	Date	Number of Standard Nets	Length of Nets (km)
Caraquet Area				
Belloni Pt. - Janeville	64-65	May 1	56	1.5
		May 15	162	4.4
		May 25	403	11.0
		June 2	466	12.8
Grindstone Pt.	65	May 15	5	0.1
		June 2	2	0.1
Blue Cove	65	May 6	160	4.4
		May 15	135	3.7
		May 20	96	2.6
		May 25	198	5.4
		June 2	575	15.8
Caraquet Is.	65	May 1	17	0.5
		May 6	21	0.6
		May 25	3	0.1
		June 2	1	0.1
Neguac Area	70	May 6	4	0.1
		May 15	55	1.5
		May 20	5	0.1
		May 25	6	0.2
		June 1	3	0.1
Escuminac Area	73			
Escuminac		April 28	2791	76.5
Escuminac		May 6	2996	82.1
Escuminac		May 15	3361	92.1
Bay du Vin		May 15	423	11.6
Escuminac		May 20	1210	33.1
Bay du Vin		May 20	156	4.3
Escuminac		May 25	430	11.7
Bay du Vin		May 25	151	4.1
Escuminac		June 1	93	2.5

(CONT'D)

Table 3 (continued)

Location	Fishery District	Date	Number of Standard Nets	Length of Nets (km)
Kouchibouguac Area	76	May 1	430	11.8
	75	May 8	10	0.3
	76	May 8	155	4.3
	75	May 15	9	0.3
	76	May 15	390	10.7
	75	May 21	28	0.8
	76	May 21	286	7.8
	75	May 25	18	0.5
	76	May 25	121	3.3
	75	June 1	6	0.2
	76	June 2	82	2.3
Shediac Area	77	May 1	507	13.9
	78	May 1	259	7.1
	77	May 8	749	20.5
	78	May 8	210	5.8
	77	May 15	837	22.9
	78	May 15	378	10.4
	77	May 20	345	9.5
	78	May 20	256	7.0
	77	May 25	292	8.0
	78	May 25	17	0.5
	77	June 1	4	0.1
North PEI	82	May 1	25	0.7
	92	May 1	459	12.6
	92	May 8	741	20.3
	82	May 15	7	0.2
	92	May 15	489	13.4
	92	May 20	255	7.0
	92	May 25	4	0.1

Table 4: Number and length of herring gillnets along the southern Gulf of St. Lawrence, spring 1983 aerial surveys.

Location	Fishery District	Date	Number of Standard Nets	Length of Nets (km)
Caraquet Area				
Belloni Pt. - Janeville	64-65	May 8	24	0.6
Blue Cove	65	May 8	87	2.4
Belloni Pt. - Janeville	64-65	May 15	87	2.4
Blue Cove - Caraquet I.	65	May 15	173	4.7
Belloni Pt. - Janeville	64-65	May 22	84	2.2
Blue Cove	65	May 22	132	3.6
Caraquet I.	65	May 22	20	0.6
Belloni Pt. - Janeville	64-65	May 29	95	2.6
Blue Cove - Caraquet I.	65	May 29	243	6.4
Blue Cove	65	June 3	199	5.5
Escuminac Area				
Escuminac	73	April 28	615	16.8
		May 2	1066	29.2
Neguac	70	May 8	6	0.2
Escuminac	73	May 8	1458	39.9
Bay du Vin	73	May 9	191	5.2
Pt. Escuminac	73	May 9	113	3.1
Neguac	70	May 14	56	1.5
Neguac	70	May 15	43	1.2
Escuminac	73	May 15	953	26.1
Escuminac	73	May 21	1577	43.2
Neguac	70	May 29	6	0.2
Escuminac	73	May 29	1169	32.0
Escuminac	73	June 1	266	7.3
Escuminac	73	June 3	73	2.0
Kouchibouguac/Richibucto Area	75-76	May 2	69	1.8
		May 9	356	9.7
		May 16	538	14.8
		May 21	60	1.6
		June 3	12	0.4

(CONT'D)

Table 4 (continued)

Location	Fishery District	Date	Number of Standard Nets	Length of Nets (km)
Shediac/Buctouche Area	77-78	May 2	15	0.5
		May 9	223	6.1
		May 16	792	21.7
		May 19	740	20.4
		May 29	150	4.2
		June 3	40	1.2
North P.E.I.	92	May 9	267	7.3
		May 16	723	19.8
		May 22	321	8.8

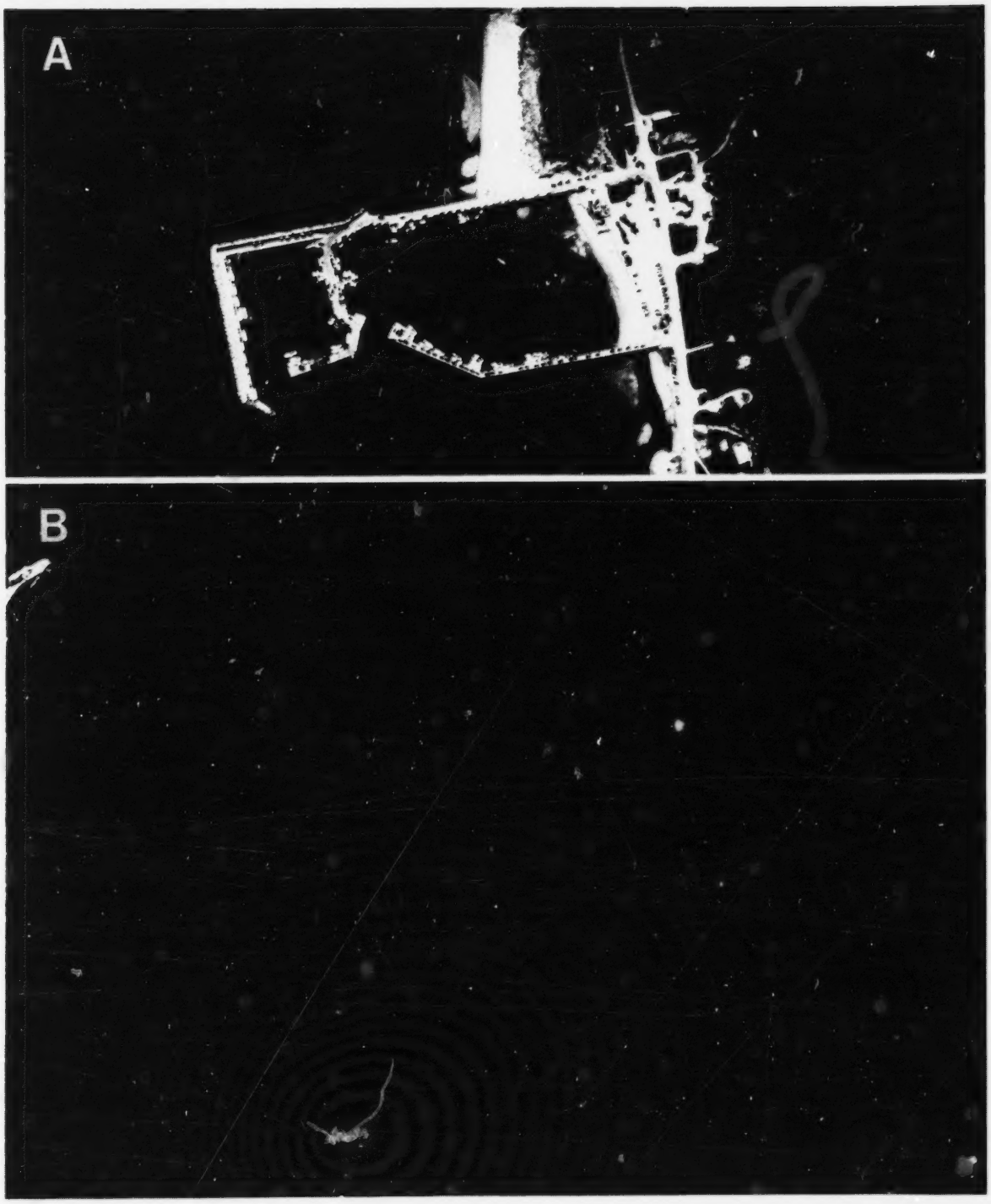


Figure 1. Aerial photograph of Escuminac area showing: (A) herring fishing boats at Escuminac Wharf; (B) herring gillnets set in water.

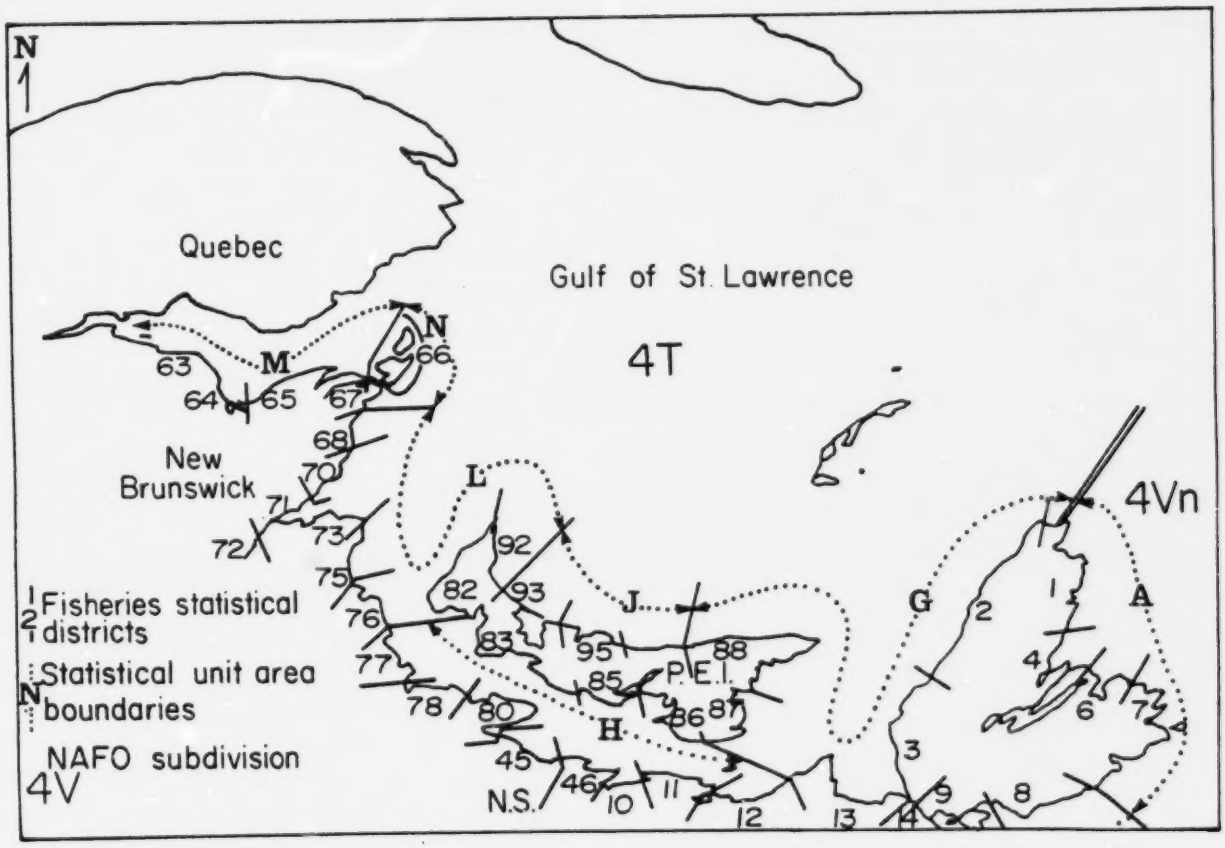


Figure 2. Map of the southern Gulf of St. Lawrence showing districts mentioned in the text.

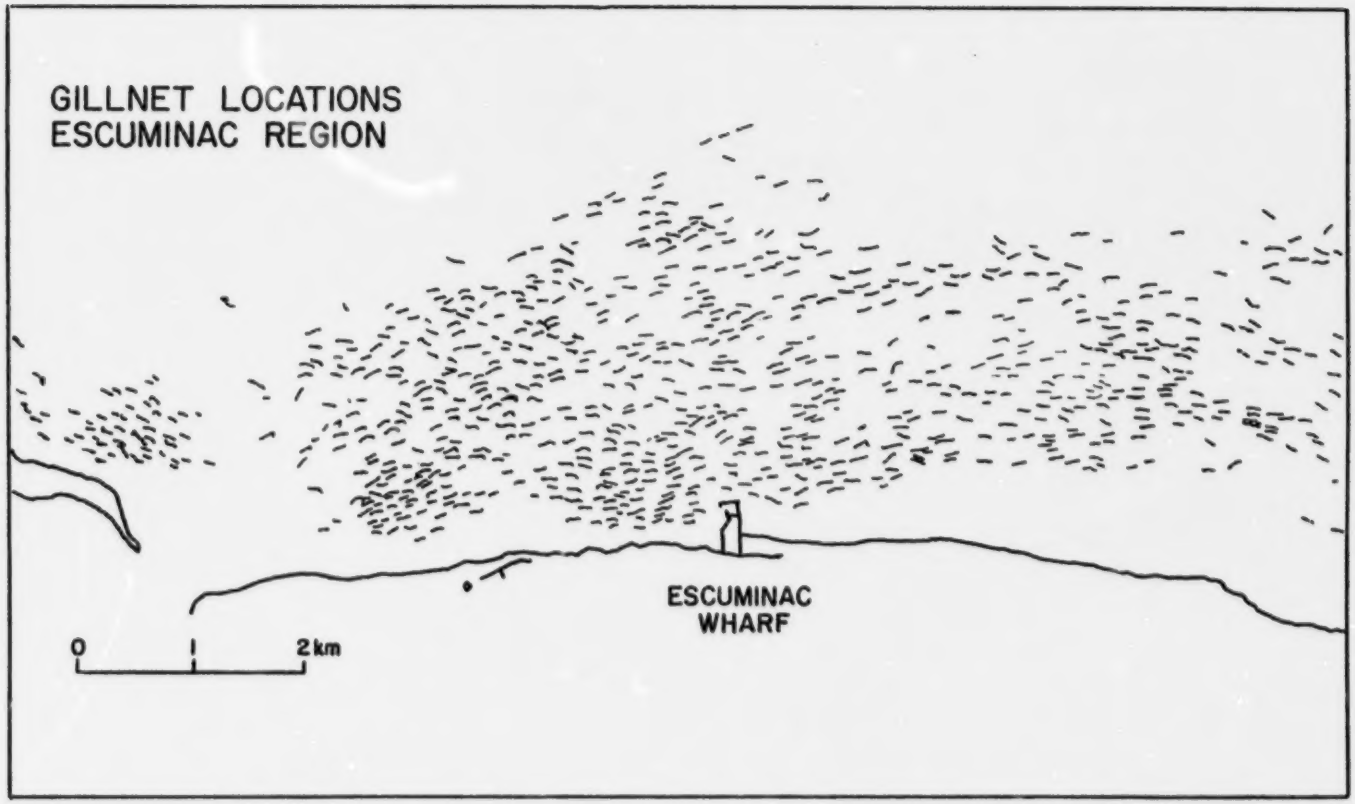


Figure 3. Herring gillnet locations in Escuminac, May 15, 1981, as shown by aerial photographic surveys.

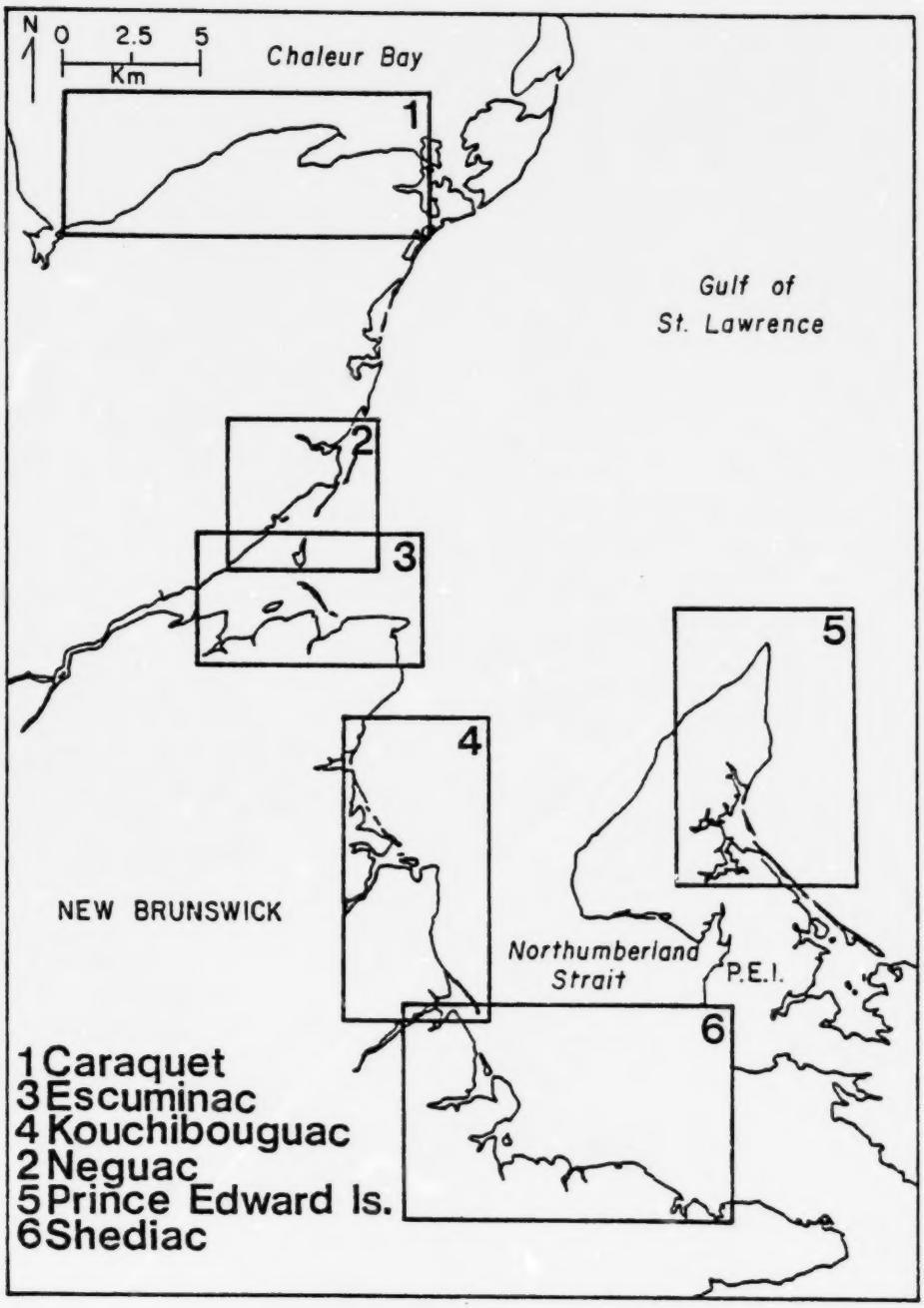
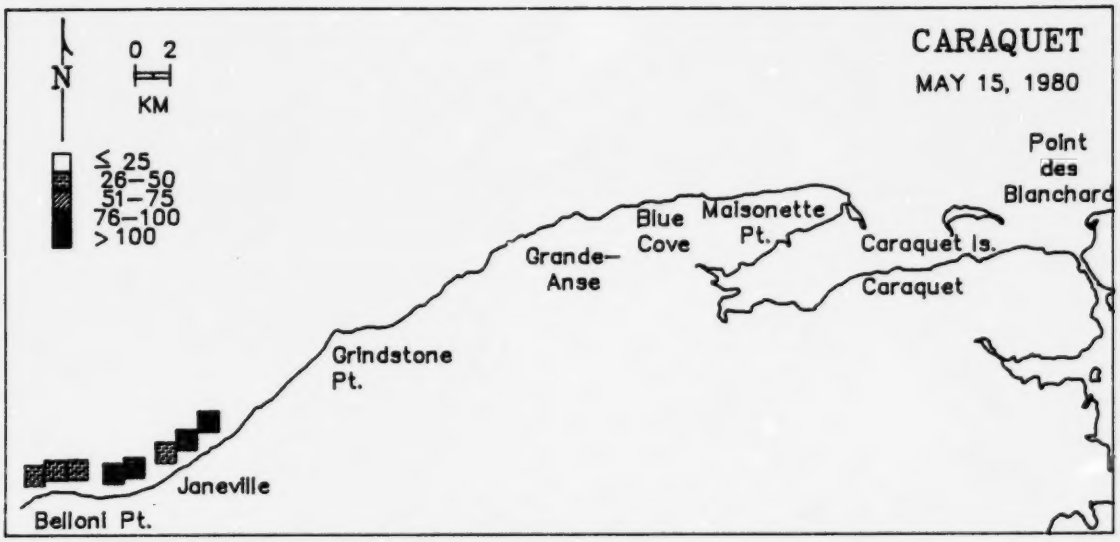


Figure 4. Map of the southern Gulf of St. Lawrence showing six areas covered by aerial surveys during 1980, 1981 and 1983.



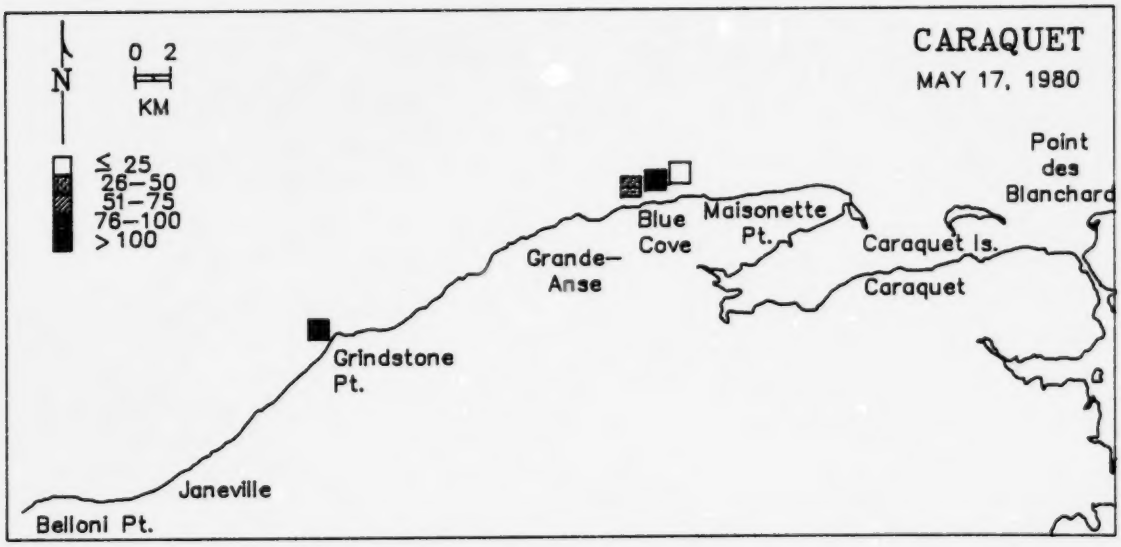
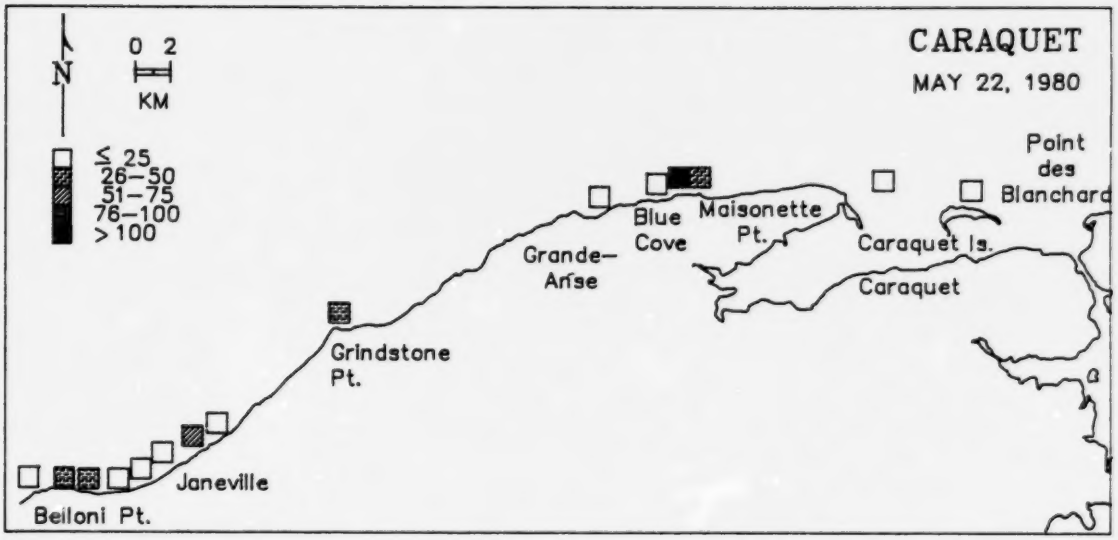
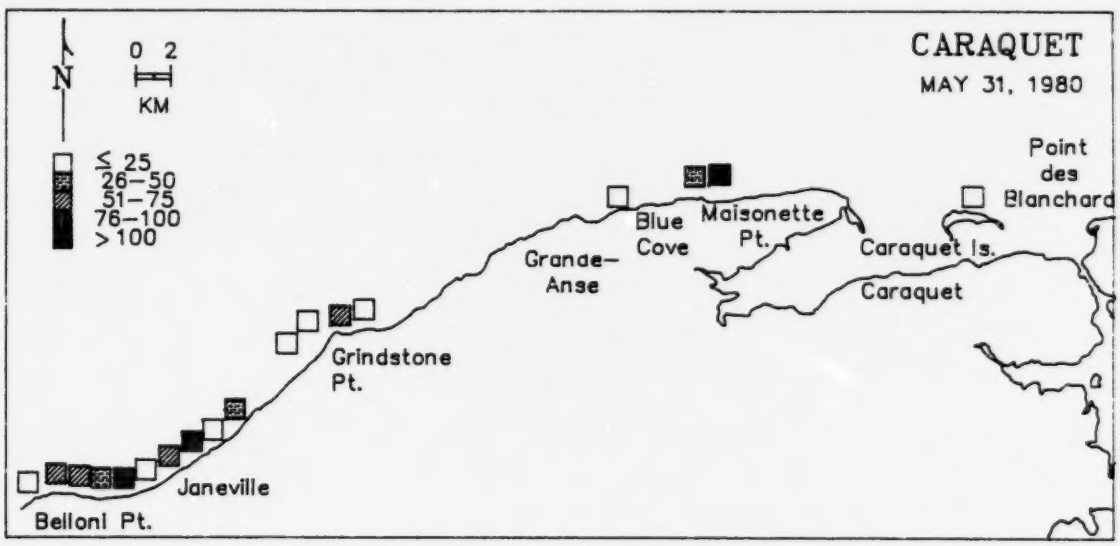
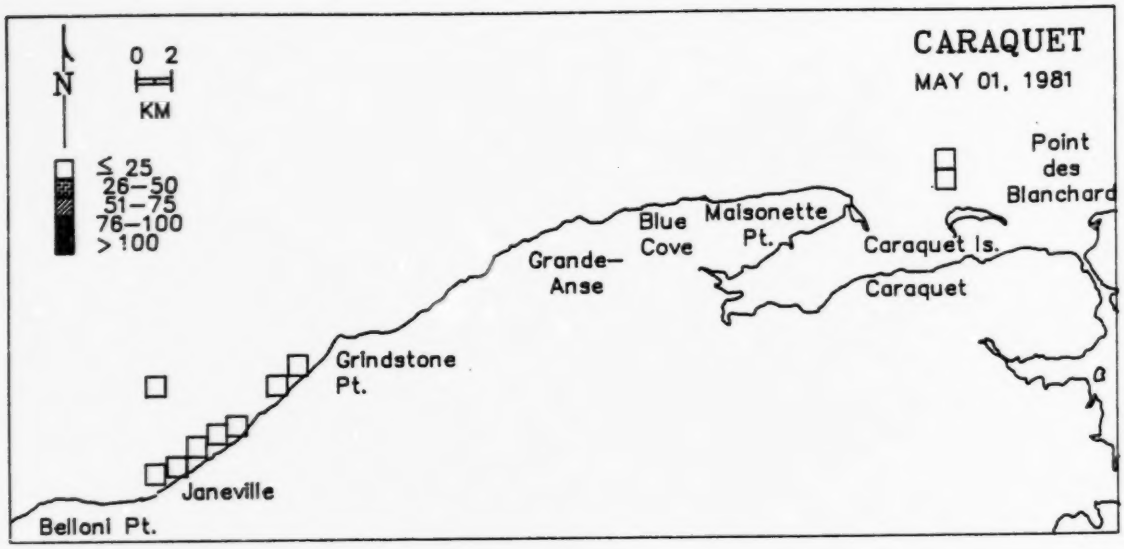
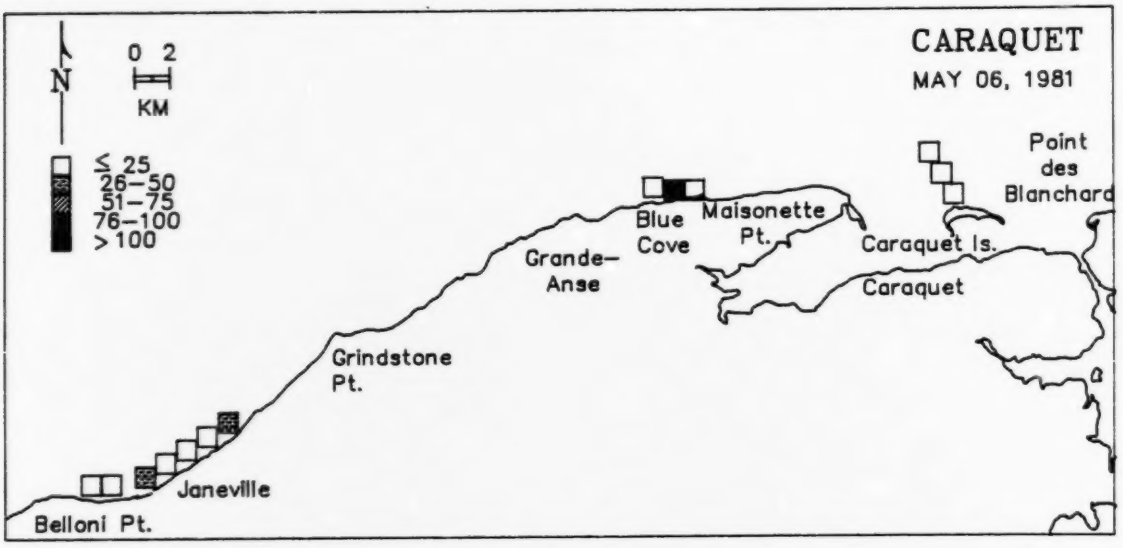


Figure 5. Distribution and density of herring gillnets in the Caraquet area, 1980.


CARAQUET
MAY 22, 1980
N
0 2
KM
≤ 25
26–50
51–75
76–100
>100
Point des Blanchard
Blue Cove
Maisonette Pt.
Caraquet Is.
Grande–Anse
Caraquet
Grindstone Pt.
Janeville
Beiloni Pt.


CARAQUET
MAY 31, 1980
N
0 2
KM
≤ 25
26–50
51–75
76–100
>100
Point des Blanchard
Blue Cove
Maisonette Pt.
Caraquet Is.
Grande–Anse
Caraquet
Grindstone Pt.
Janeville
Beiloni Pt.





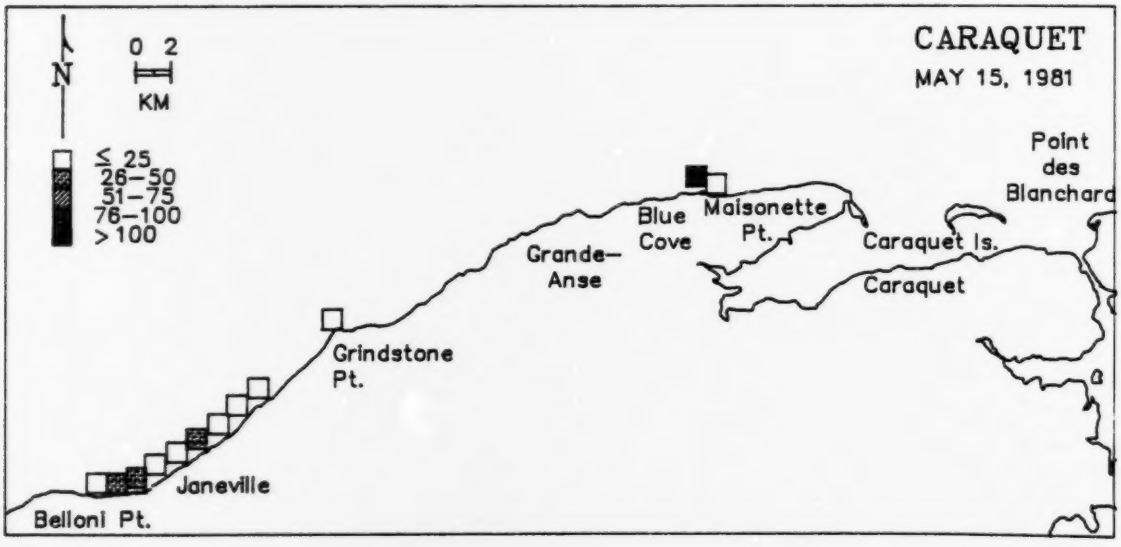
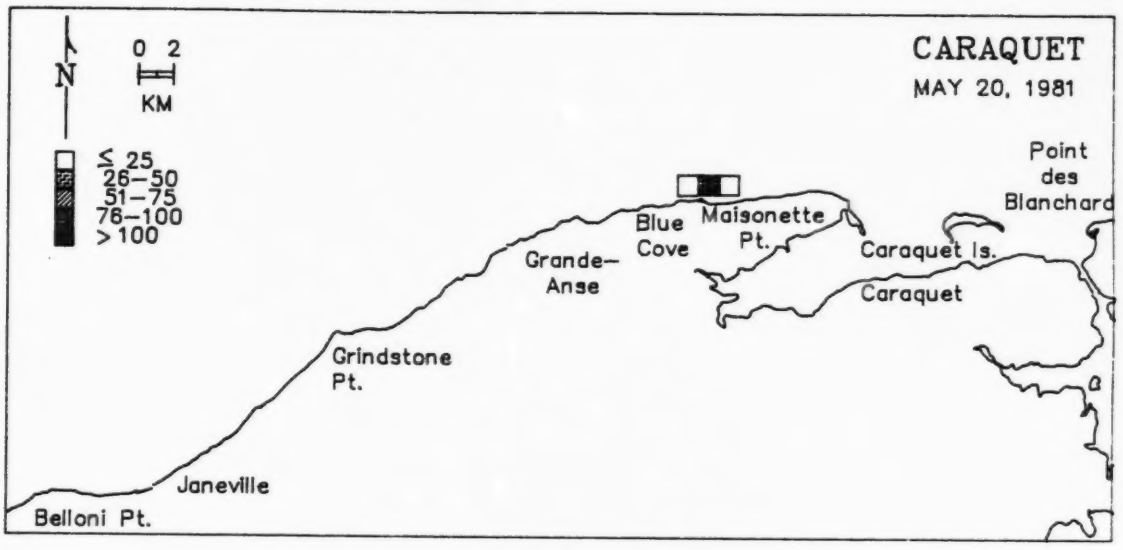
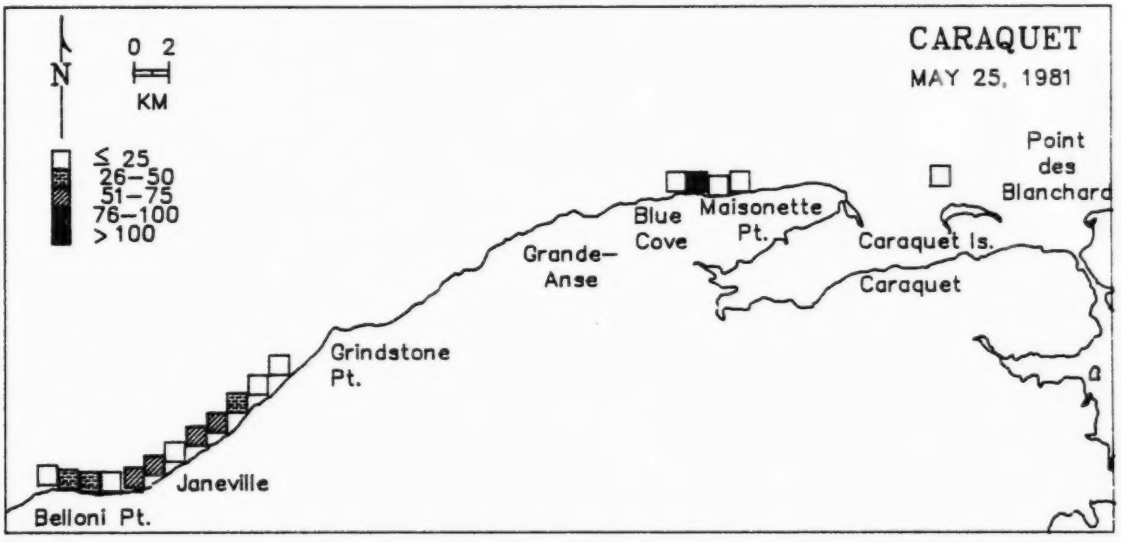
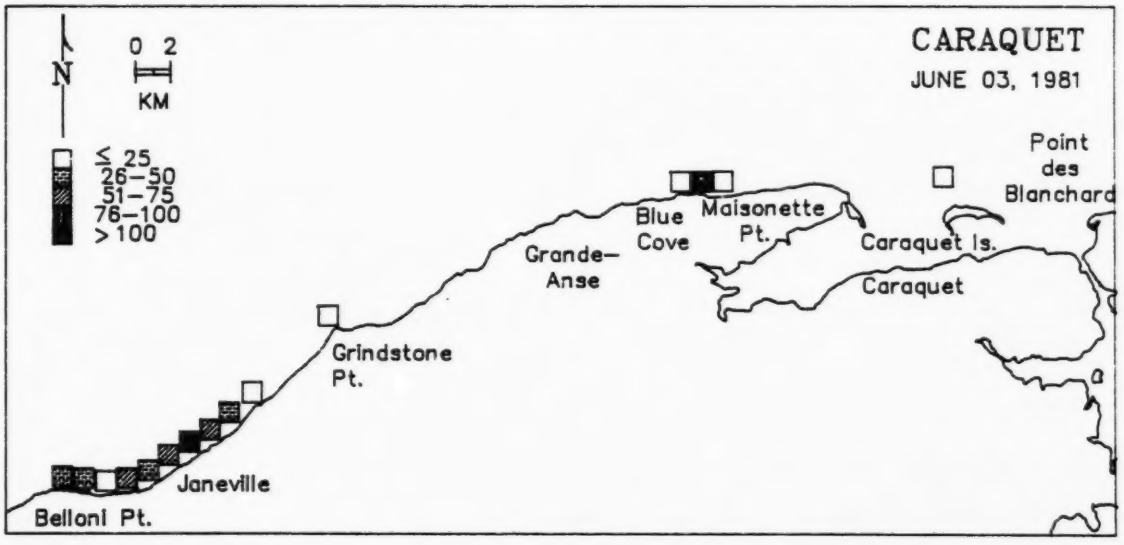
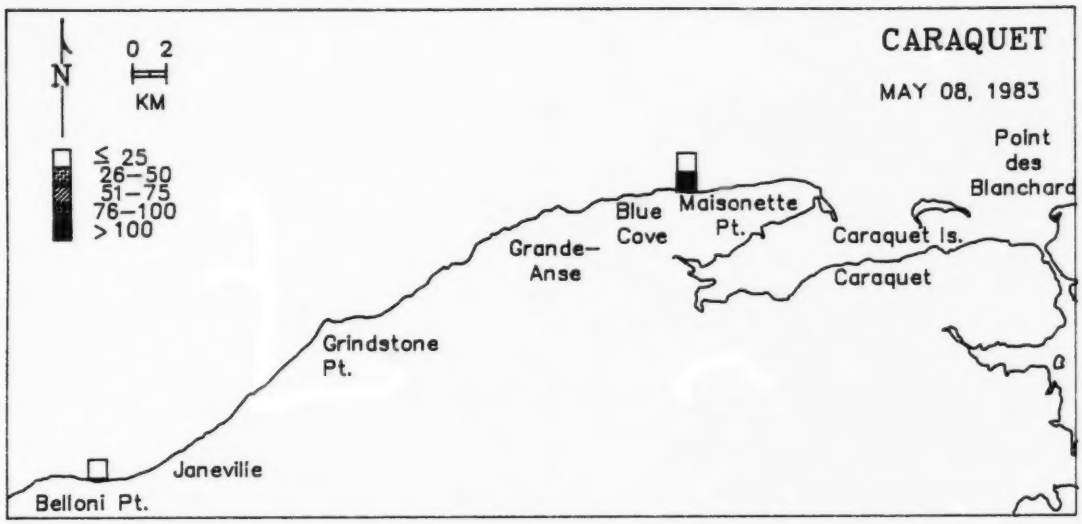


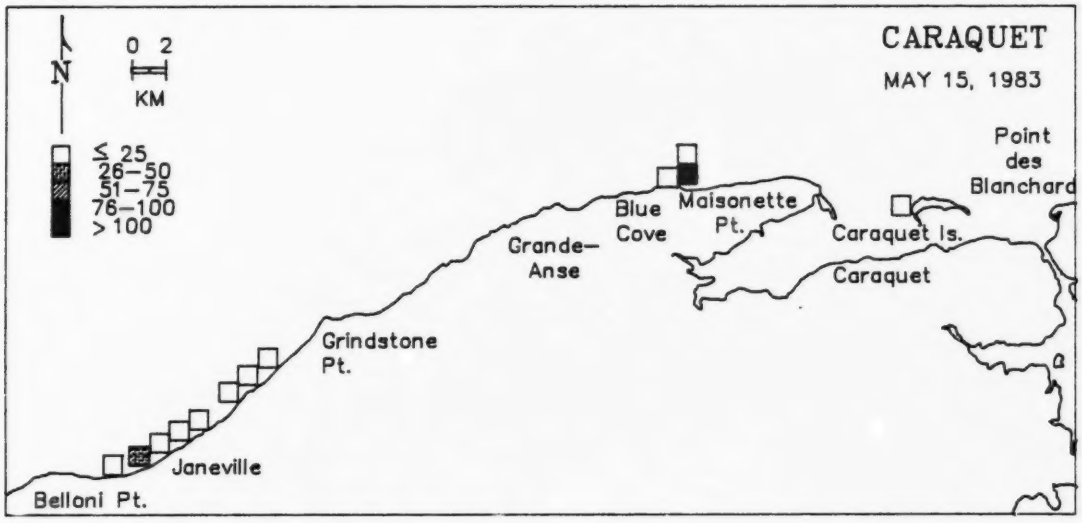
Figure 6. Distribution and density of herring gillnets in the Caraquet area, 1981.


N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
CARAQUET
MAY 20, 1981
Point des Blanchard
Blue Cove
Maisonette Pt.
Caraquet Is.
Grande–Anse
Caraquet
Grindstone Pt.
Janeville
Belloni Pt.


N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
CARAQUET
MAY 25, 1981
Point des Blanchard
Blue Cove
Maisonette Pt.
Caraquet Is.
Grande–Anse
Caraquet
Grindstone Pt.
Janeville
Belloni Pt.


N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
CARAQUET
JUNE 03, 1981
Point des Blanchard
Blue Cove
Maisonette Pt.
Caraquet Is.
Grande–Anse
Caraquet
Grindstone Pt.
Janeville
Belloni Pt.





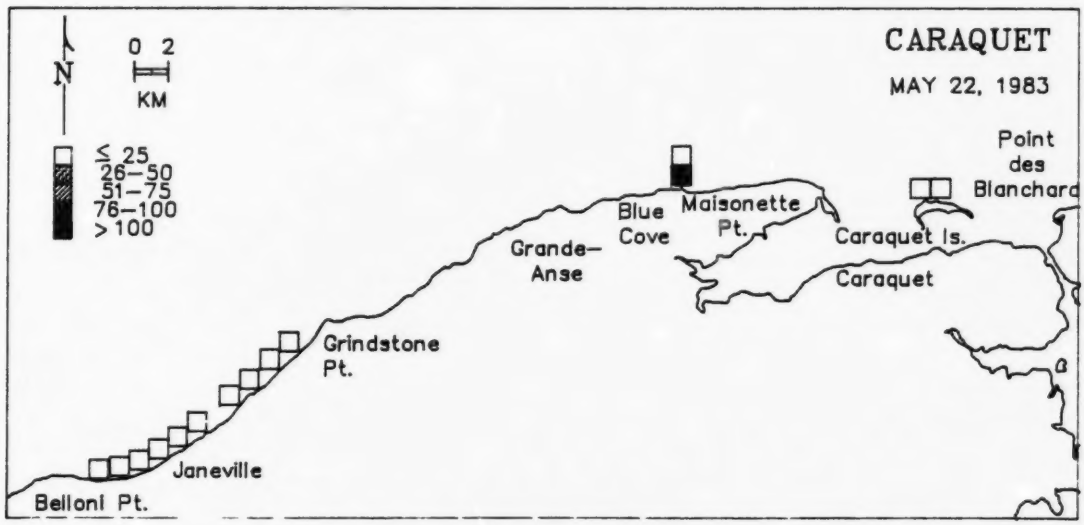
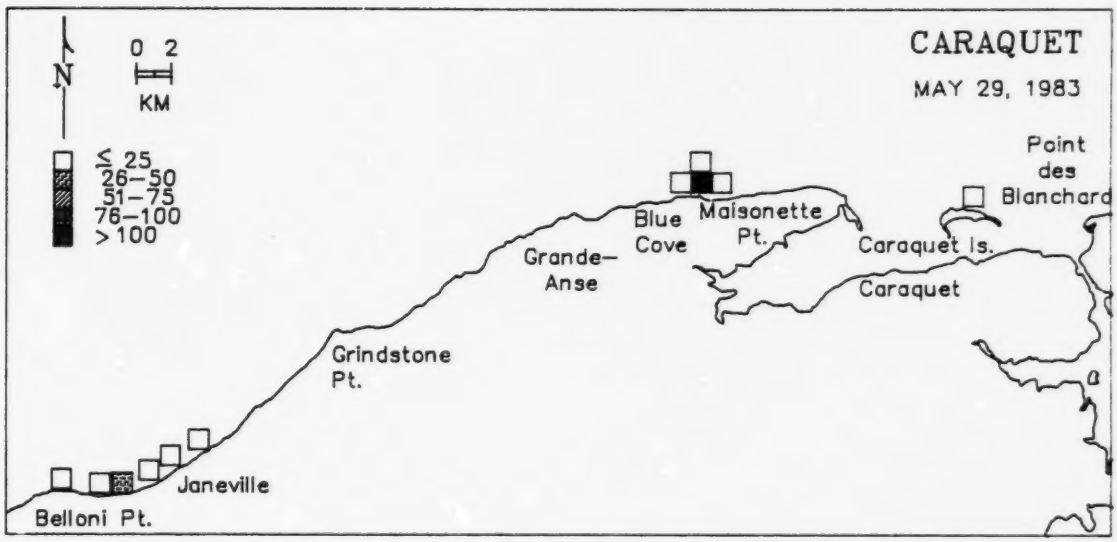
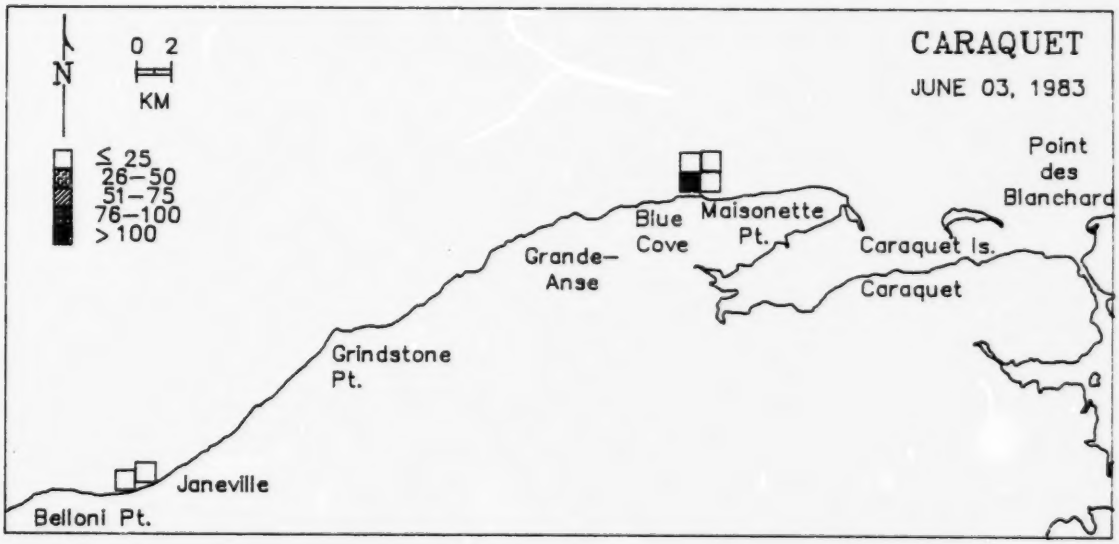


Figure 7. Distribution and density of herring gillnets in the Caraquet area, 1983.


CARAQUET
MAY 29, 1983
N
0 2
KM
≤ 25
26–50
51–75
76–100
>100
Point des Blanchard
Maisonette Pt.
Blue Cove
Grande–Anse
Caraquet Is.
Caraquet
Grindstone Pt.
Janeville
Belloni Pt.


CARAQUET
JUNE 03, 1983
N
0 2
KM
≤ 25
26–50
51–75
76–100
>100
Point des Blanchard
Maisonette Pt.
Blue Cove
Grande–Anse
Caraquet Is.
Caraquet
Grindstone Pt.
Janeville
Belloni Pt.

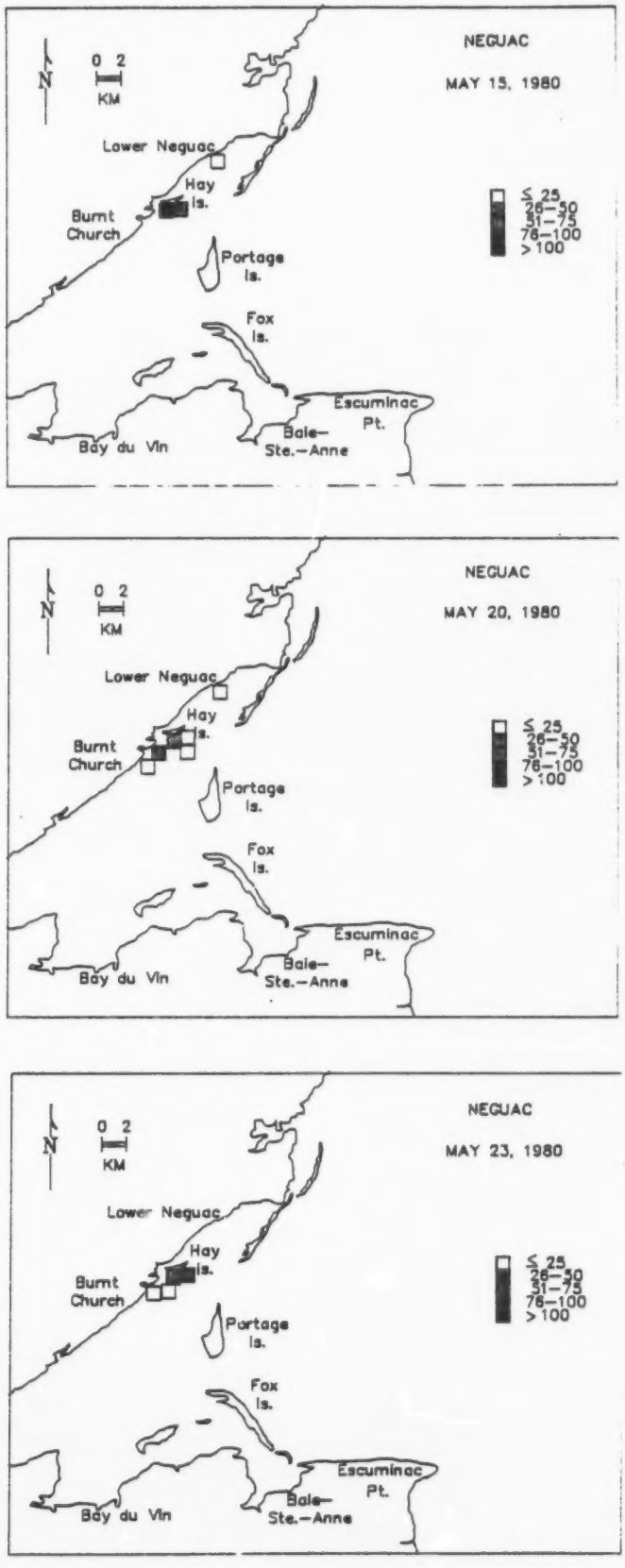


Figure 8. Distribution and density of herring gillnets in the Neguac area, 1980.

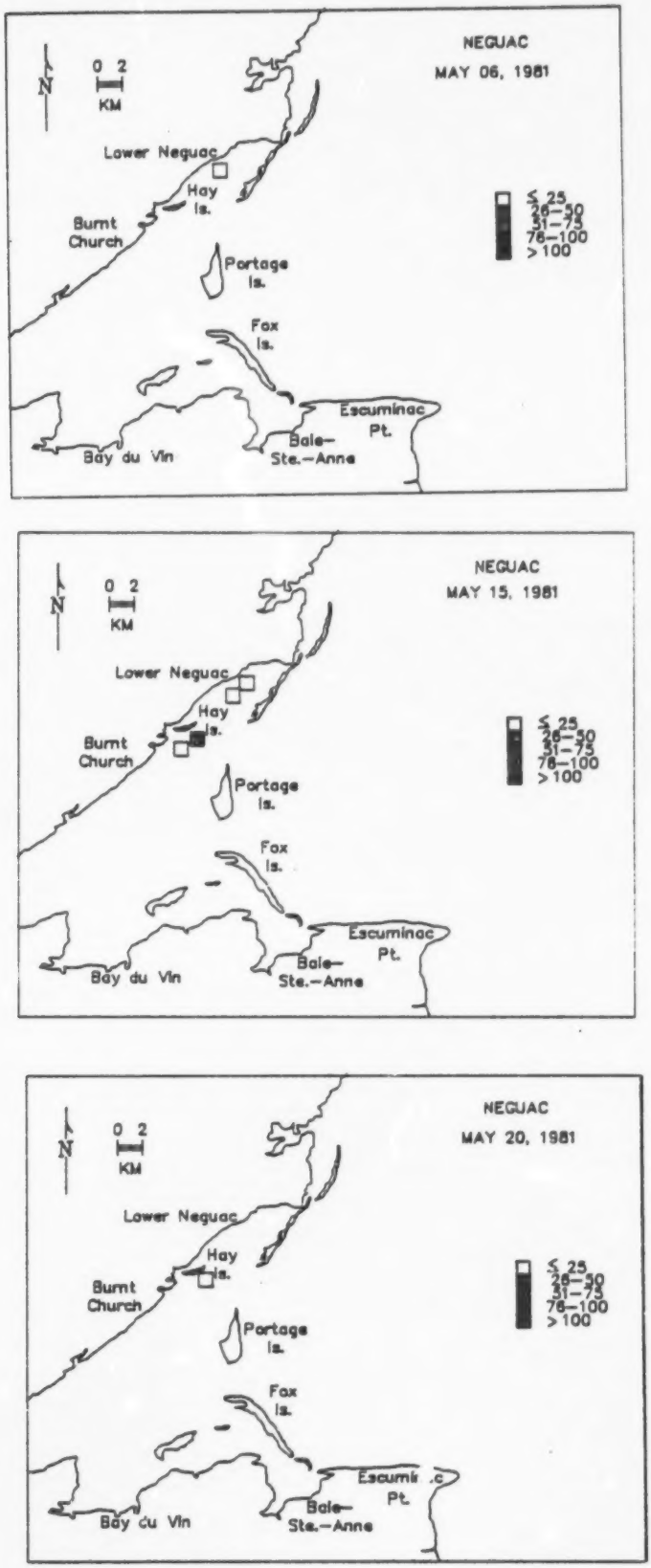
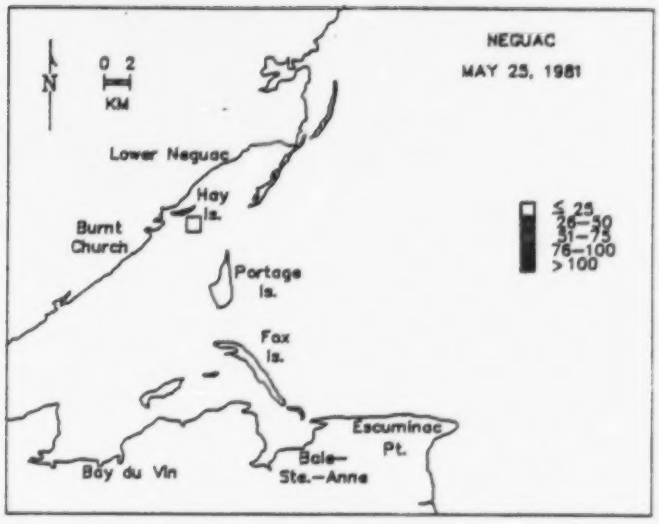
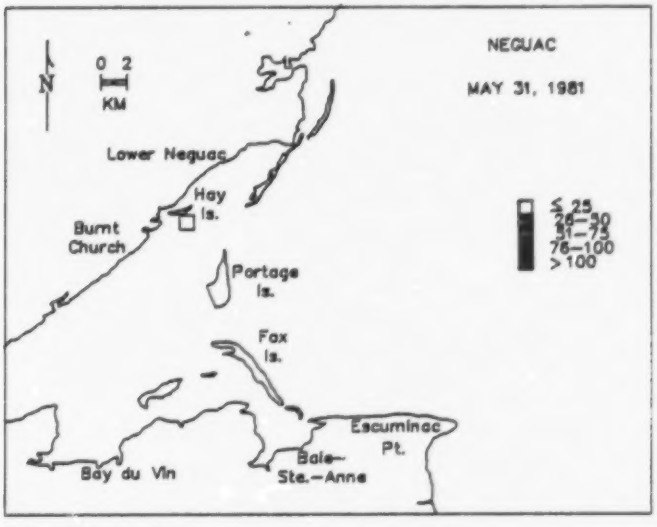
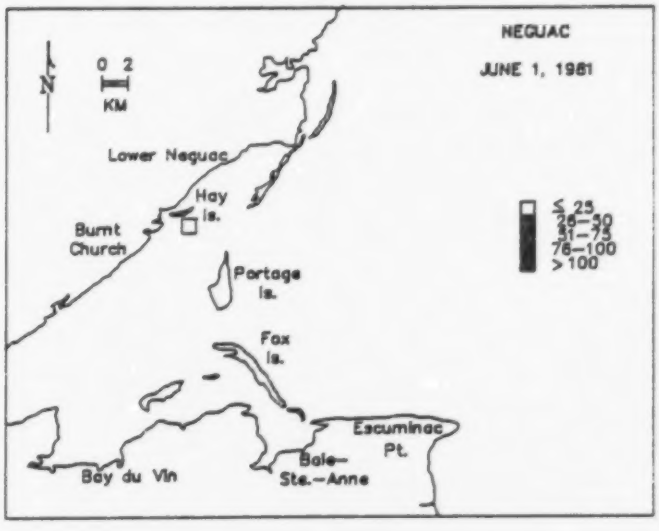
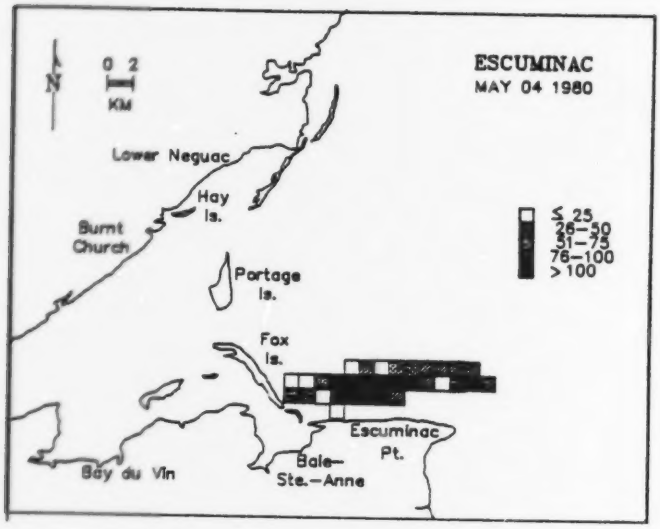


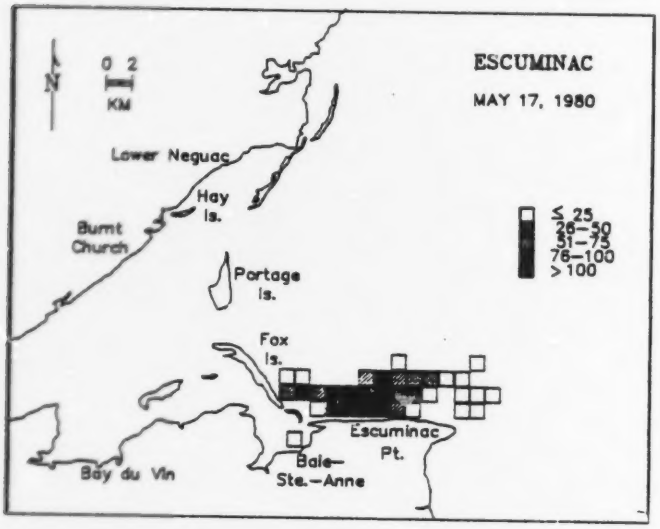
Figure 9. Distribution and density of herring gillnets in the Neguac area, 1981.


NEGUAC
MAY 25, 1981
N
0 2
KM
Lower Neguac
Hay
Is.
Burnt
Church
Portage
Is.
Fax
Is.
Escuminac
Pt.
Bay du Vin
Baie-
Ste.-Anne
≤ 25
26–30
31–75
76–100
> 100


NEGUAC
MAY 31, 1981
N
0 2
KM
Lower Neguac
Hay
Is.
Burnt
Church
Portage
Is.
Fax
Is.
Escuminac
Pt.
Bay du Vin
Baie-
Ste.-Anne
≤ 25
26–30
31–75
76–100
> 100


NEGUAC
JUNE 1, 1981
N
0 2
KM
Lower Neguac
Hay
Is.
Burnt
Church
Portage
Is.
Fax
Is.
Escuminac
Pt.
Bay du Vin
Baie-
Ste.-Anne
≤ 25
26–30
31–75
76–100
> 100





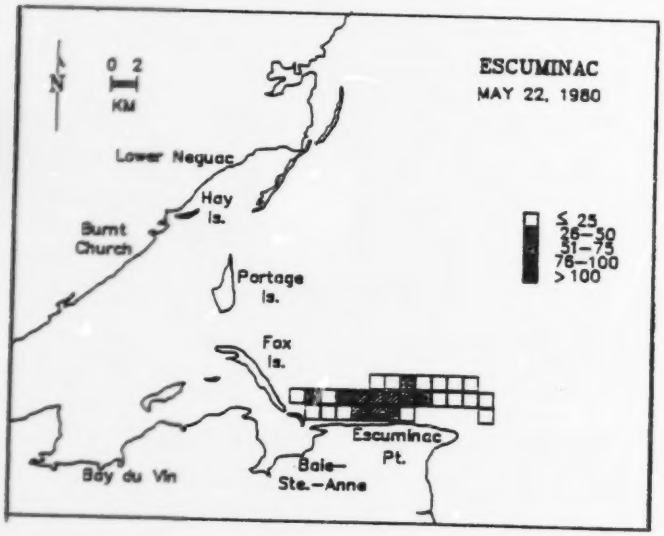
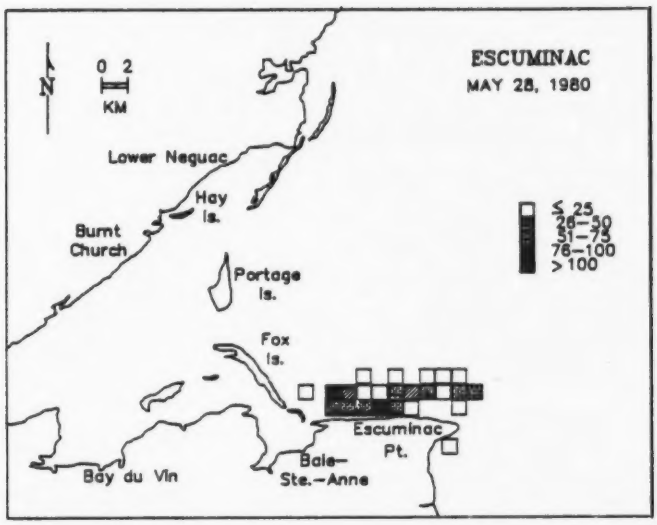
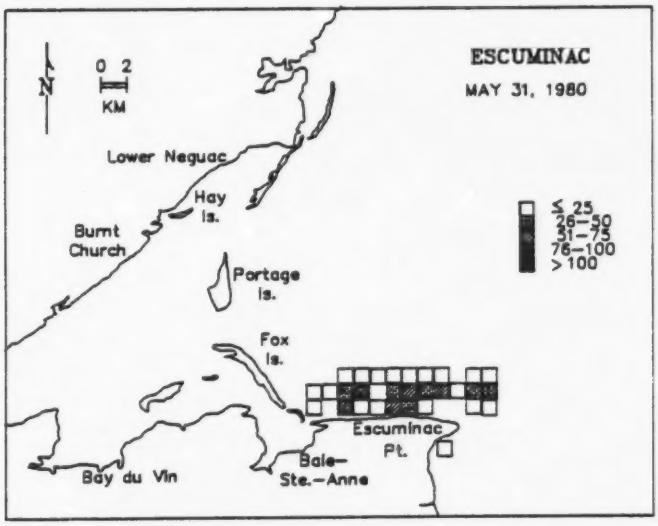
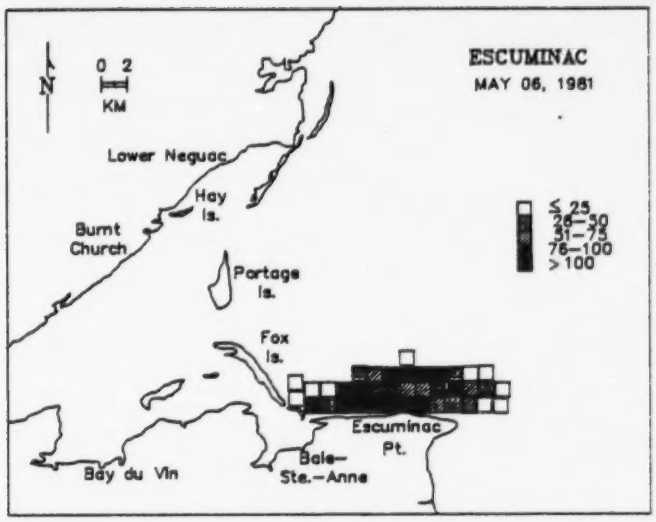
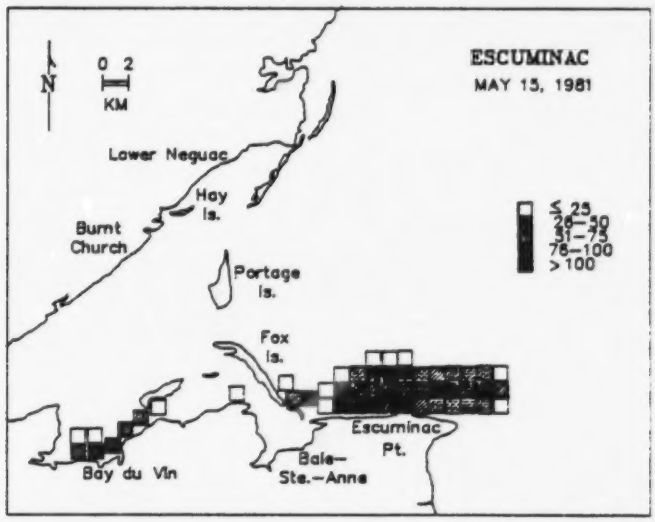


Figure 10. Distribution and density of herring gillnets in the Escuminac area, 1980.


ESCUMINAC
MAY 28, 1980
N
0 2
KM
Lower Neguac
Hay
Is.
Burnt
Church
Portage
Is.
Fox
Is.
Escuminac
Pt.
Bay du Vin
Baie-
Ste.-Anne
≤ 25
26-50
51-75
76-100
> 100


ESCUMINAC
MAY 31, 1980
N
0 2
KM
Lower Neguac
Hay
Is.
Burnt
Church
Portage
Is.
Fox
Is.
Escuminac
Pt.
Bay du Vin
Baie-
Ste.-Anne
≤ 25
26-50
51-75
76-100
> 100





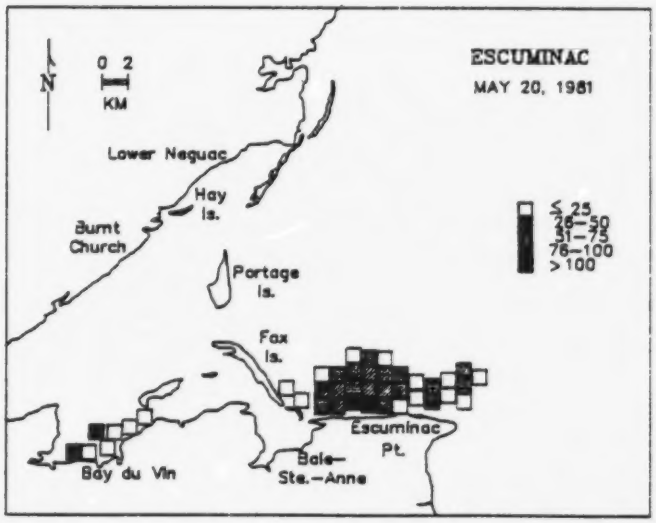
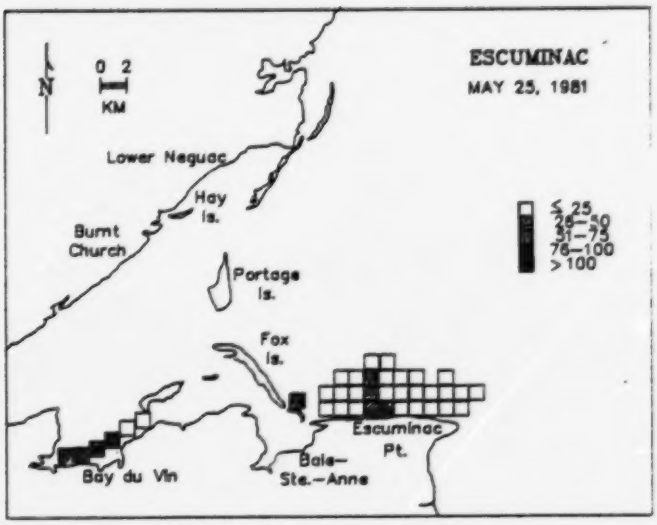
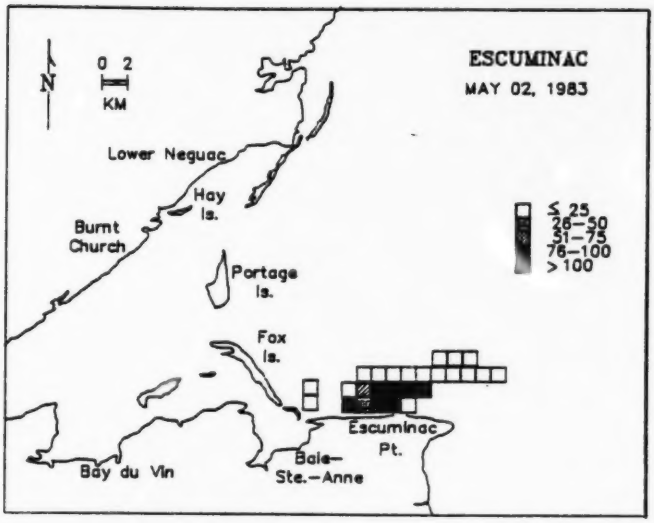
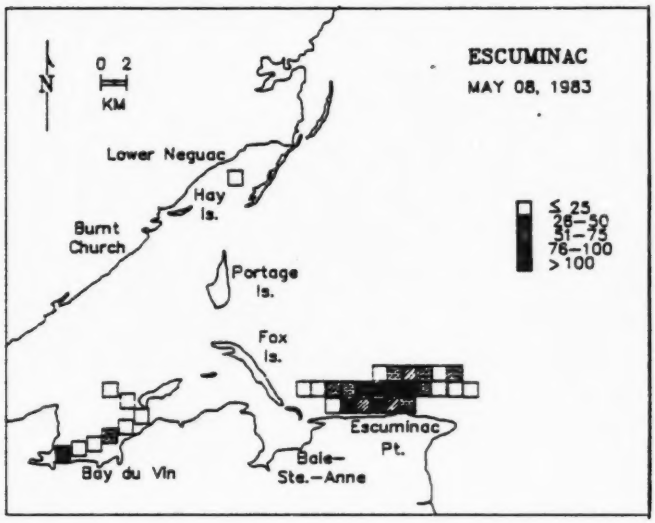


Figure 11. Distribution and density of herring gillnets in the Escuminac area, 1981.


ESCUMINAC
MAY 25, 1981
N
0 2
KM
Lower Neguac
Hay
Is.
Burnt
Church
Portage
Is.
Fox
Is.
Escuminac
Pt.
Baie-
Ste.-Anne
Bay du Vin
≤ 25
26–50
51–75
76–100
> 100





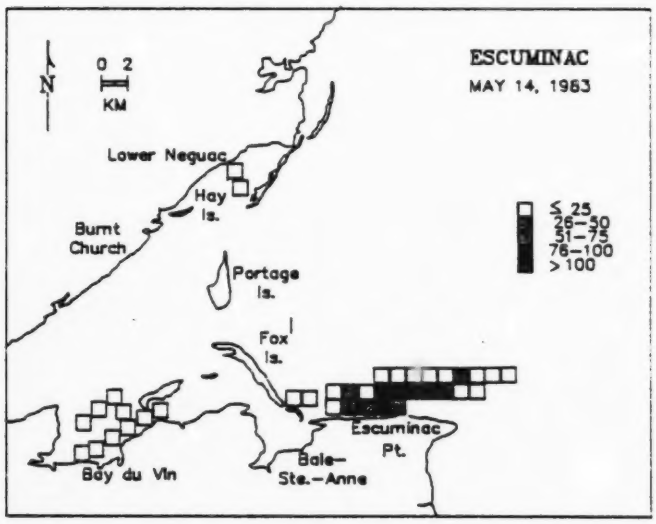
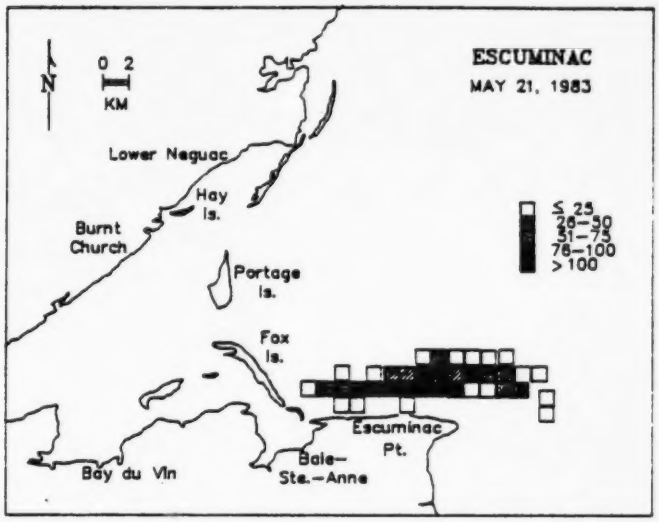
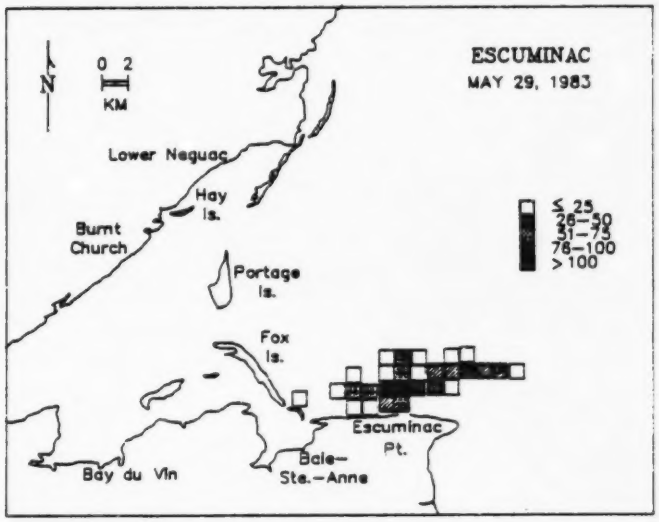
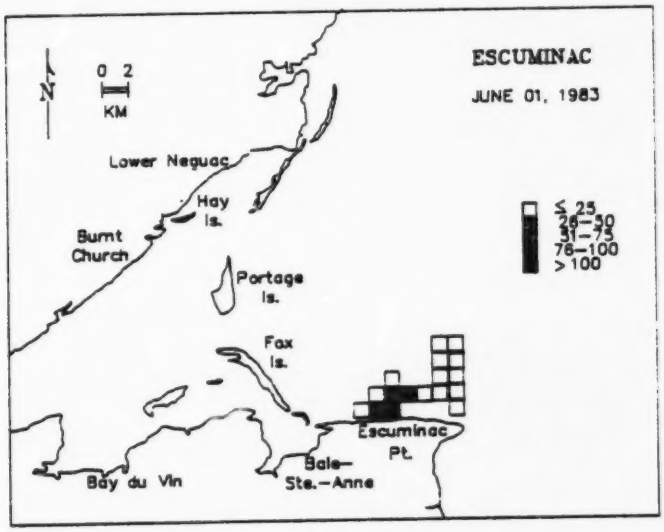


Figure 12. Distribution and density of herring gillnets in the Escuminac area, 1983.


N
0 2
KM
ESCUMINAC
MAY 21, 1983
≤ 25
26–30
31–75
76–100
>100
Lower Neguac
Hay Is.
Burnt Church
Portage Is.
Fox Is.
Escuminac Pt.
Bay du Vin
Baie-Ste.-Anne


N
0 2
KM
ESCUMINAC
MAY 29, 1983
≤ 25
26–30
31–75
76–100
>100
Lower Neguac
Hay Is.
Burnt Church
Portage Is.
Fox Is.
Escuminac Pt.
Bay du Vin
Baie-Ste.-Anne


N
0 2
KM
ESCUMINAC
JUNE 01, 1983
≤ 25
26–30
31–75
76–100
>100
Lower Neguac
Hay Is.
Burnt Church
Portage Is.
Fox Is.
Escuminac Pt.
Bay du Vin
Baie-Ste.-Anne

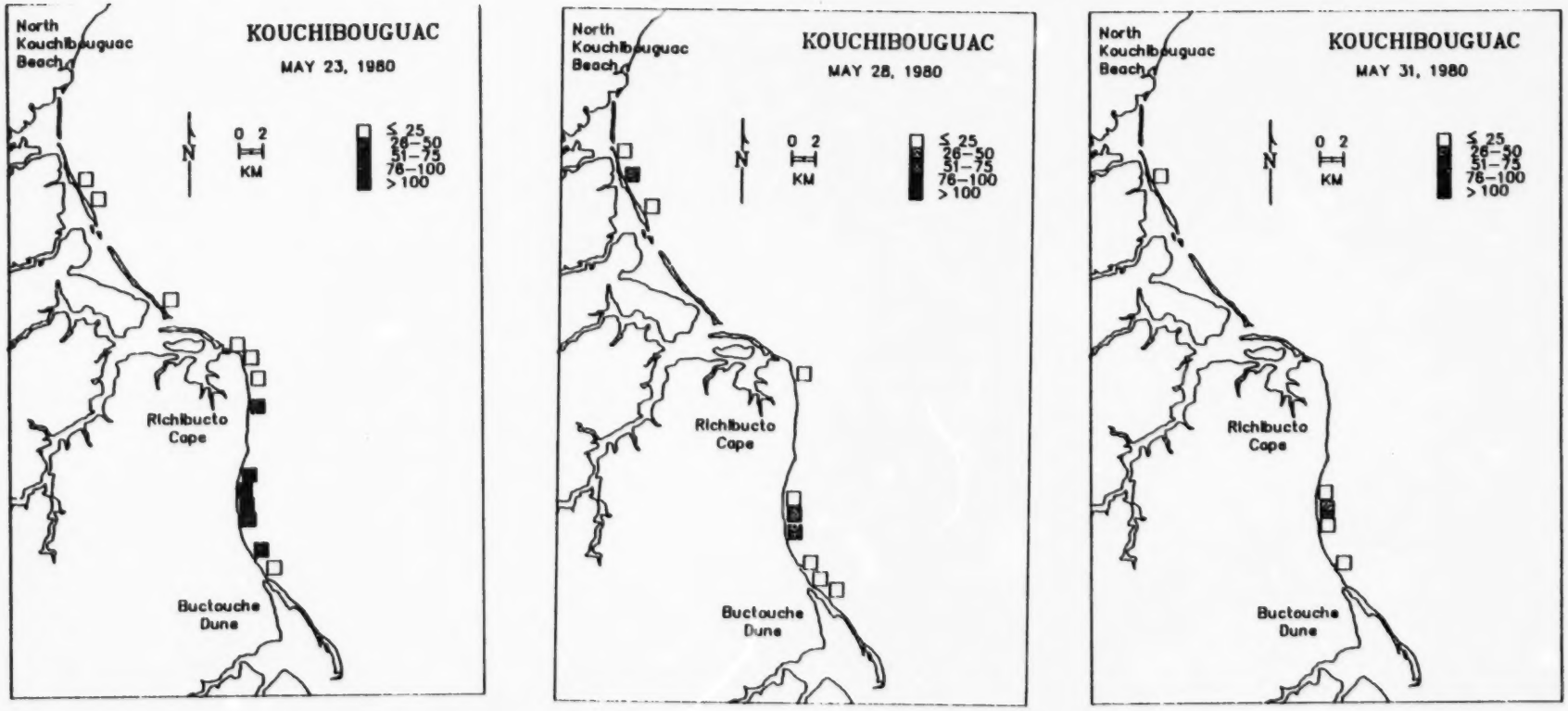


Figure 13. Distribution and density of herring gillnets in the Kouchibouguac area, 1980.

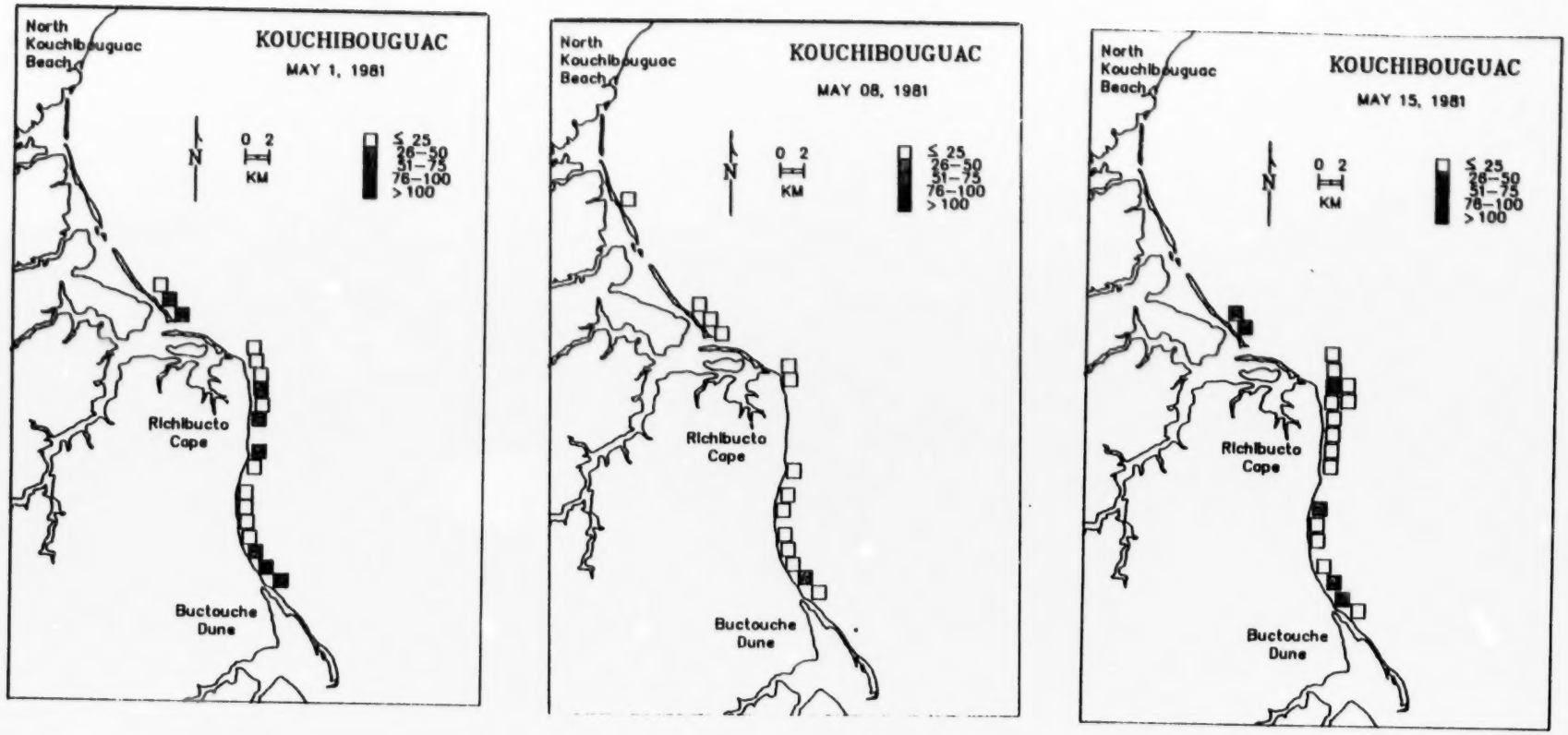
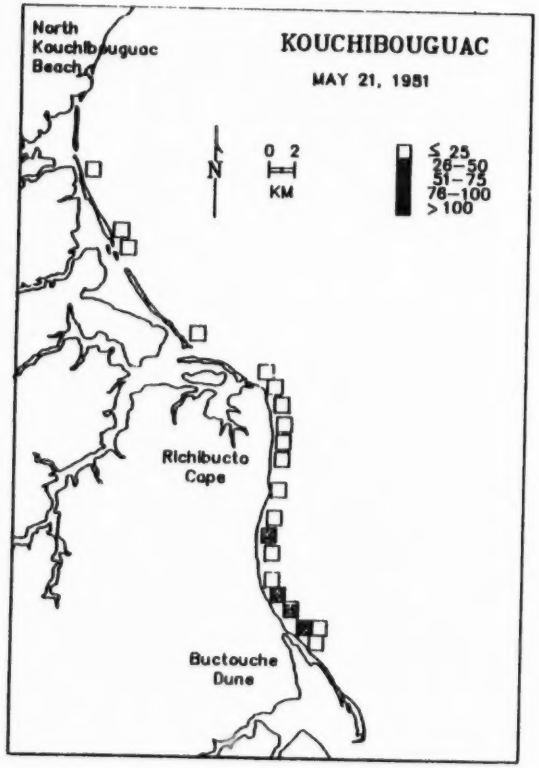
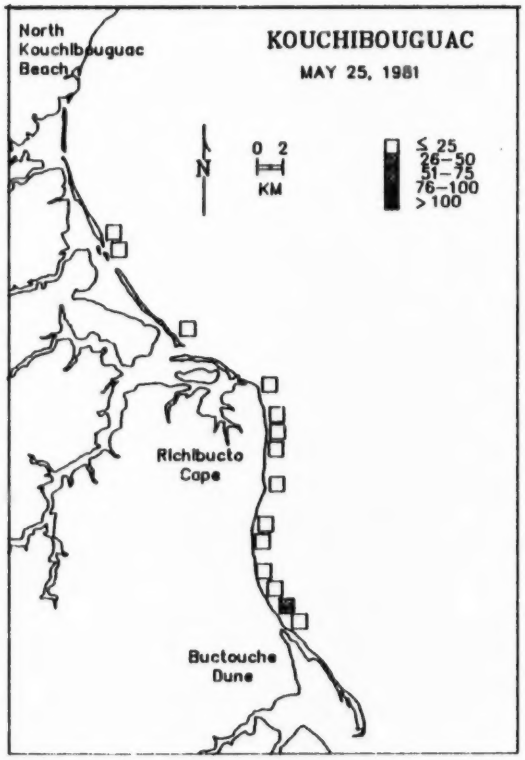
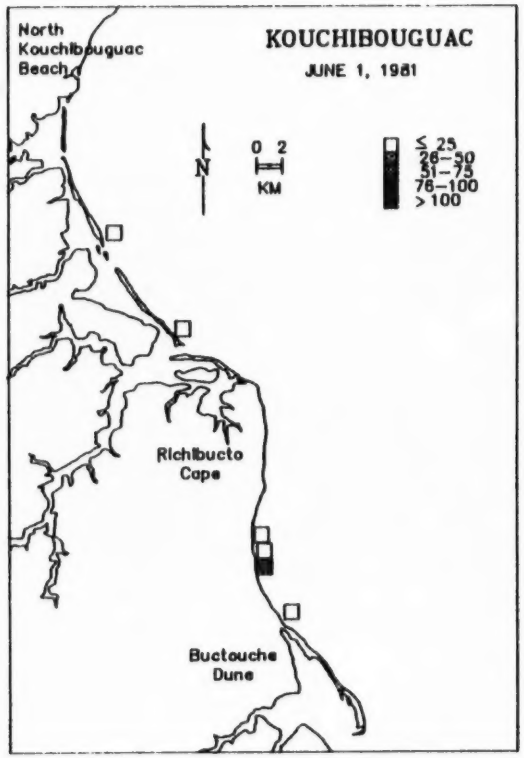


Figure 14. Distribution and density of herring gillnets in the Kouchibouguac area, 1981.


North
Kouchibouguac
Beach
KOUCHIBOUGUAC
MAY 21, 1981
N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
Richibucto
Cape
Buctouche
Dune


North
Kouchibouguac
Beach
KOUCHIBOUGUAC
MAY 25, 1981
N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
Richibucto
Cape
Buctouche
Dune


North
Kouchibouguac
Beach
KOUCHIBOUGUAC
JUNE 1, 1981
N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
Richibucto
Cape
Buctouche
Dune

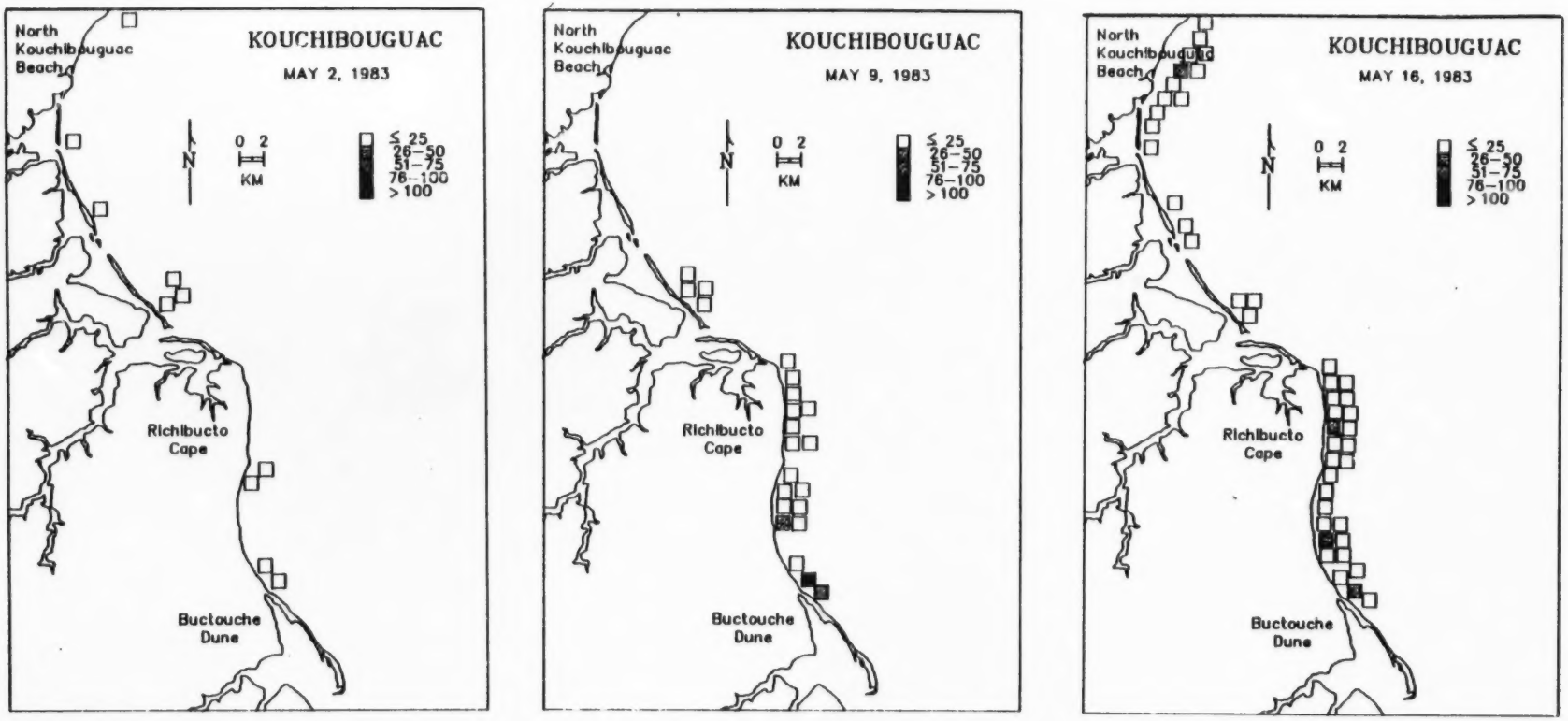
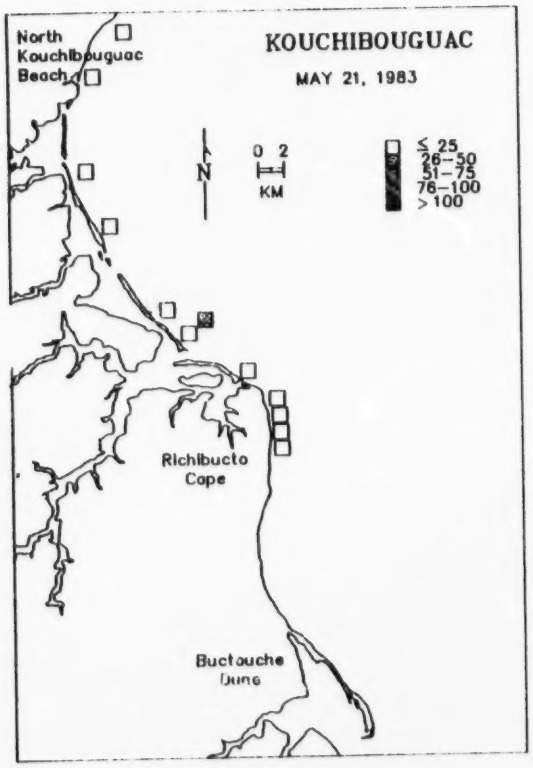
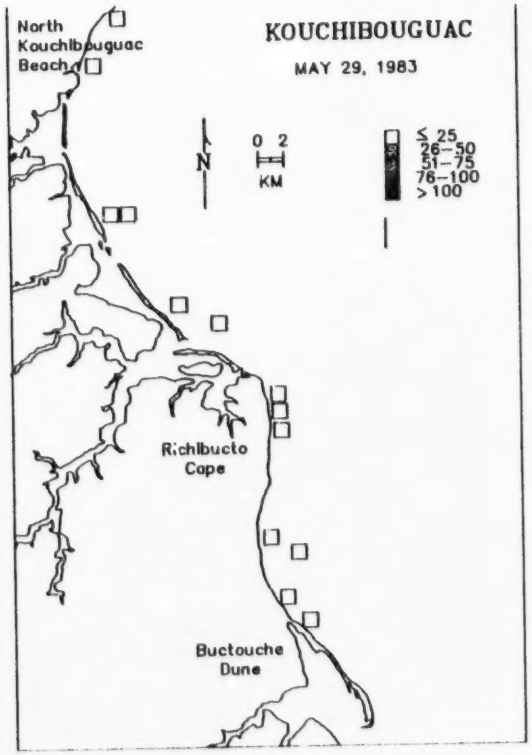
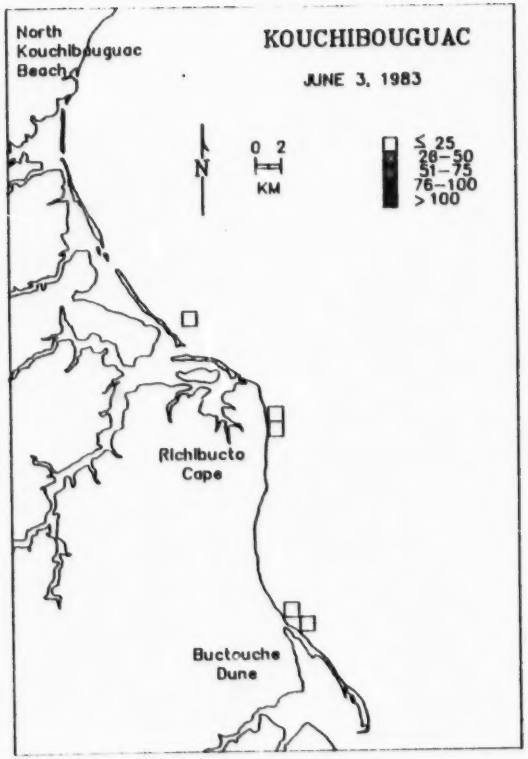
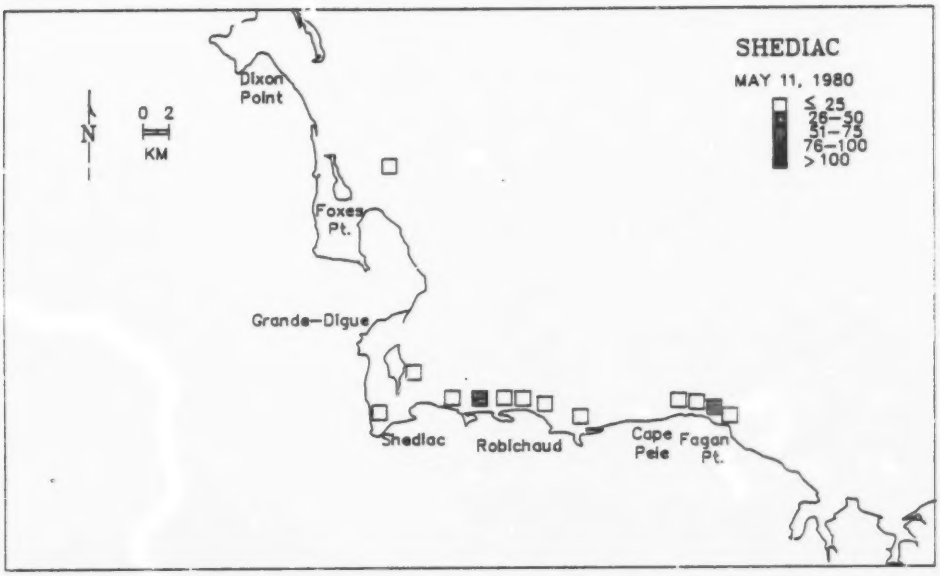


Figure 15. Distribution and density of herring gillnets in the Kouchibouguac area, 1983.


North
Kouchibouguac
Beach
KOUCHIBOUGUAC
MAY 21, 1983
N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
Richibucto
Cape
Buctouche
Dune


North
Kouchibouguac
Beach
KOUCHIBOUGUAC
MAY 29, 1983
N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
Richibucto
Cape
Buctouche
Dune


North
Kouchibouguac
Beach
KOUCHIBOUGUAC
JUNE 3, 1983
N
0 2
KM
≤ 25
26–50
51–75
76–100
> 100
Richibucto
Cape
Buctouche
Dune



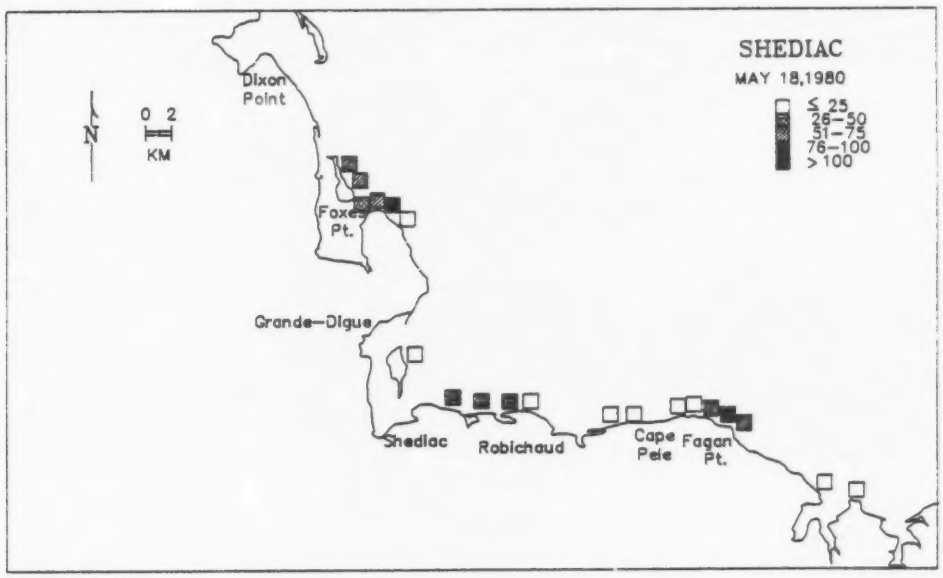
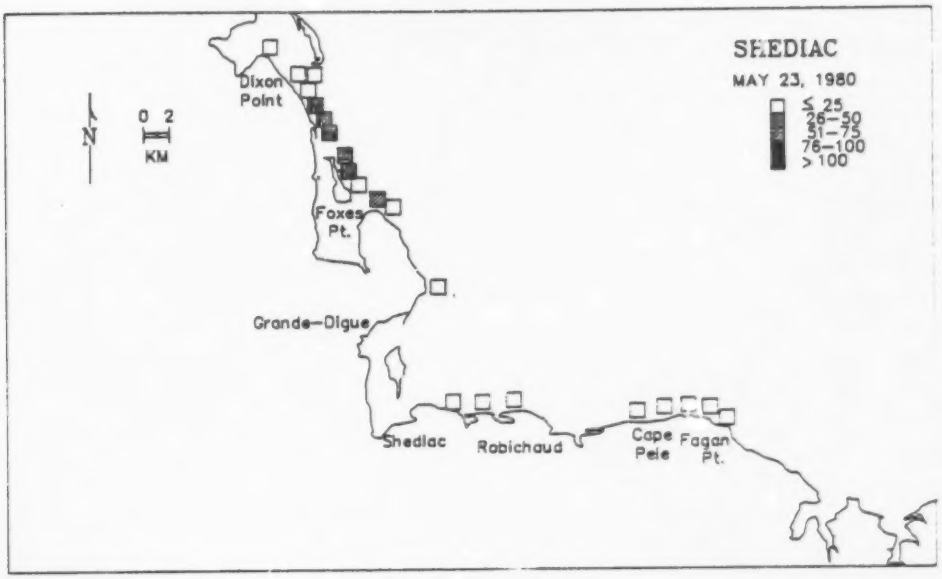
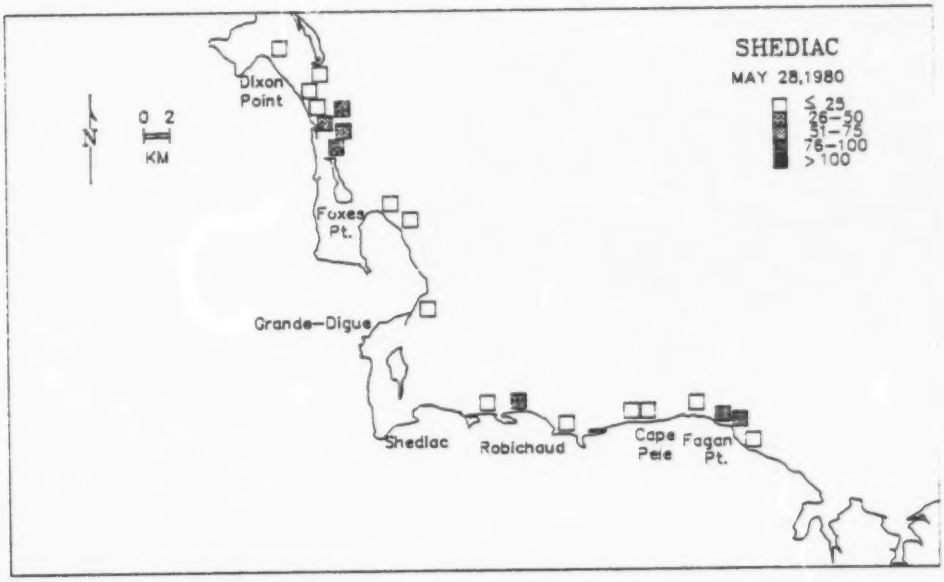


Figure 16. Distribution and density of herring gillnets in the Shediac area, 1980.


SHEDIAC
MAY 23, 1980
≤ 25
26–50
51–75
76–100
> 100
N
0 2
KM
Dixon Point
Foxes Pt.
Grande–Digue
Shediac
Robichaud
Cape Pele
Fagan Pt.


SHEDIAC
MAY 28,1980
≤ 25
26–50
51–75
76–100
> 100
N
0 2
KM
Dixon Point
Foxes Pt.
Grande–Digue
Shediac
Robichaud
Cape Pele
Fagan Pt.

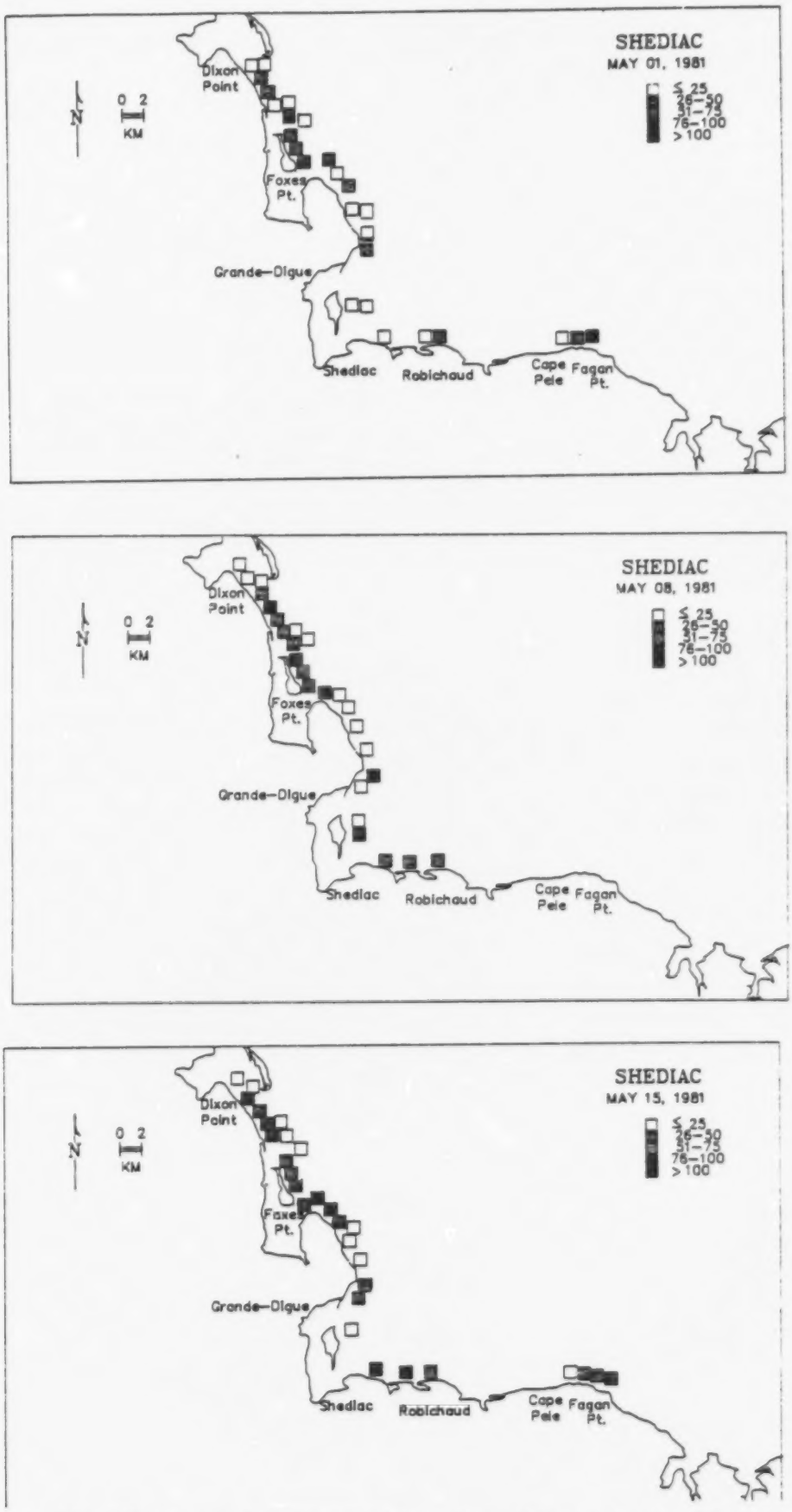
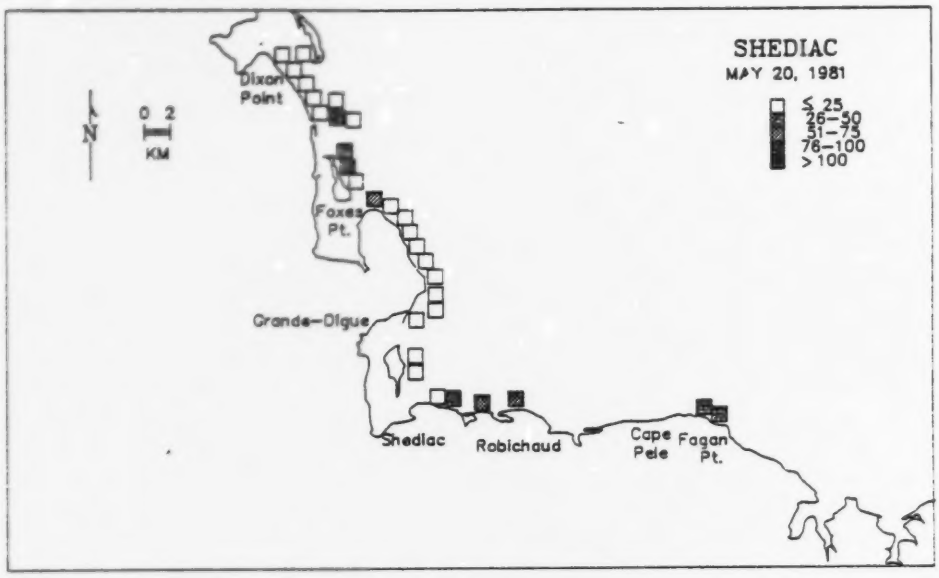
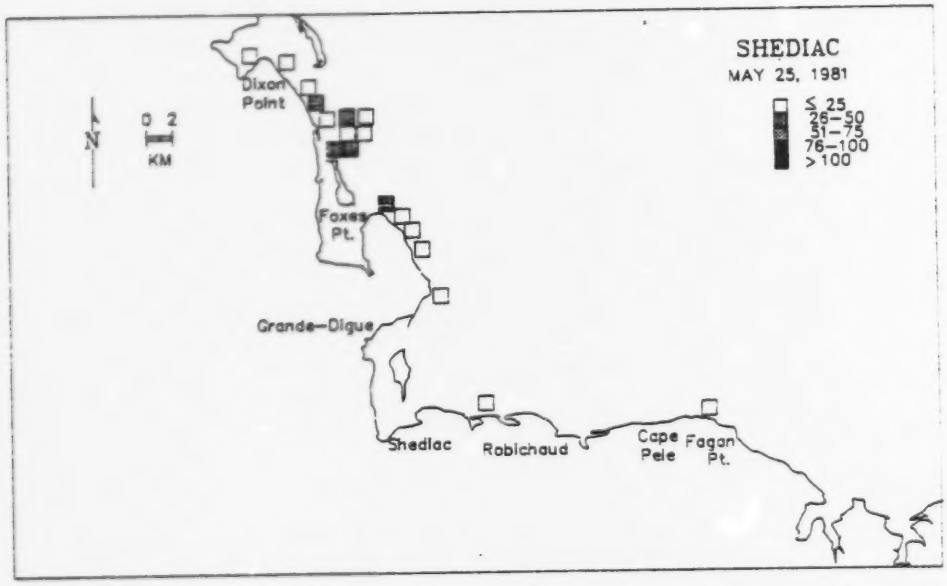
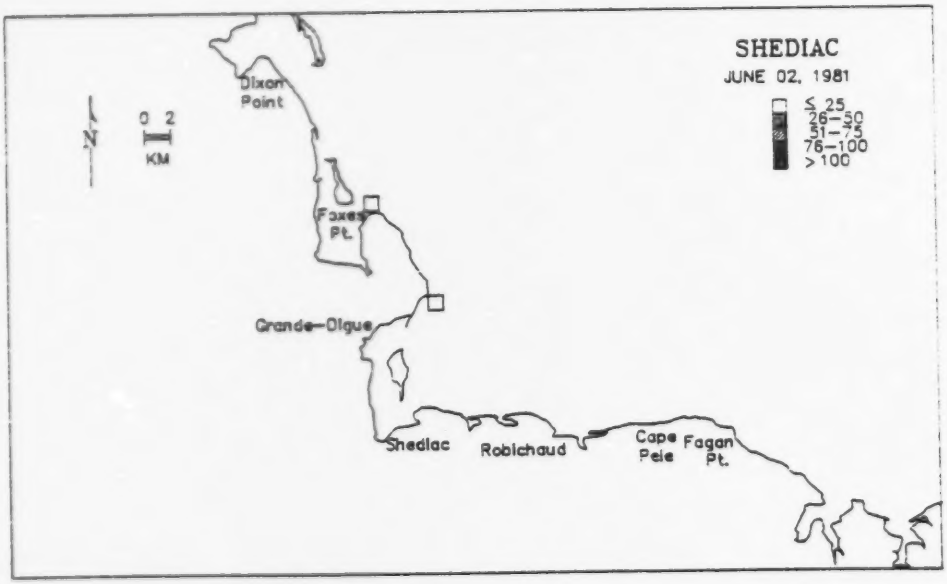
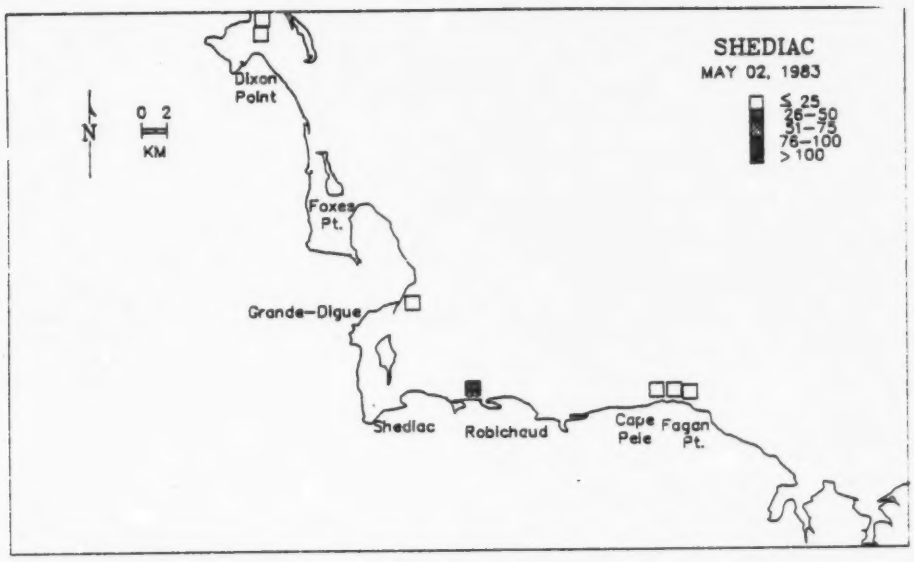


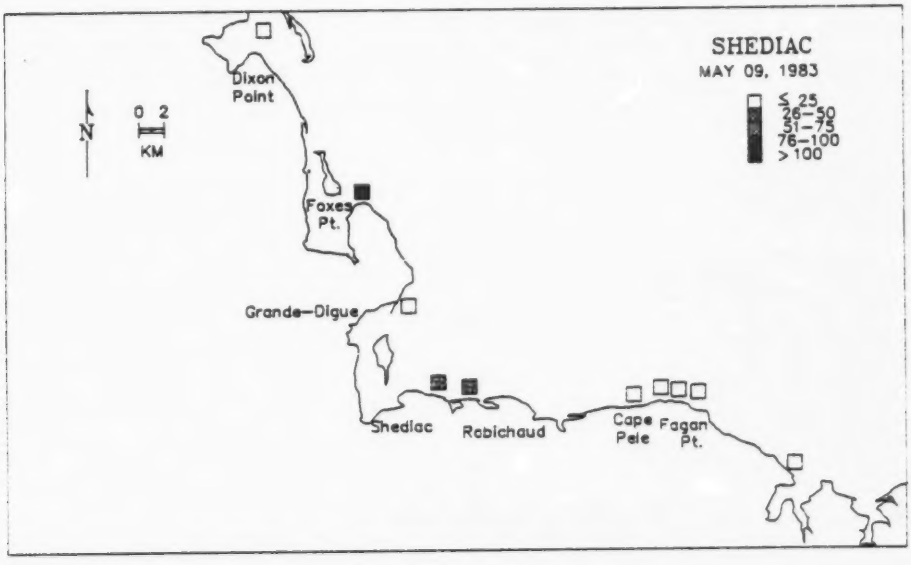
Figure 17. Distribution and density of herring gillnets in the Shediac area, 1981.


SHEDIAC
MAY 20, 1981
≤ 25
26–50
51–75
76–100
>100
N
0 2
KM
Dixon Point
Foxes Pt.
Grande–Digue
Shediac
Robichaud
Cape Pele
Fagan Pt.


SHEDIAC
MAY 25, 1981
≤ 25
26–50
51–75
76–100
>100
N
0 2
KM
Dixon Point
Foxes Pt.
Grande–Digue
Shediac
Robichaud
Cape Pele
Fagan Pt.


SHEDIAC
JUNE 02, 1981
≤ 25
26–50
51–75
76–100
>100
N
0 2
KM
Dixon Point
Foxes Pt.
Grande–Digue
Shediac
Robichaud
Cape Pele
Fagan Pt.





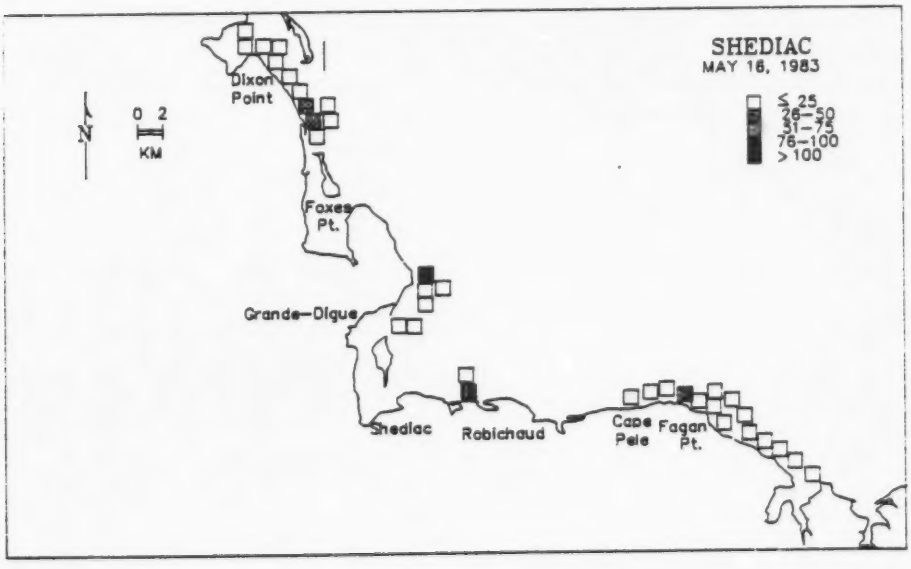
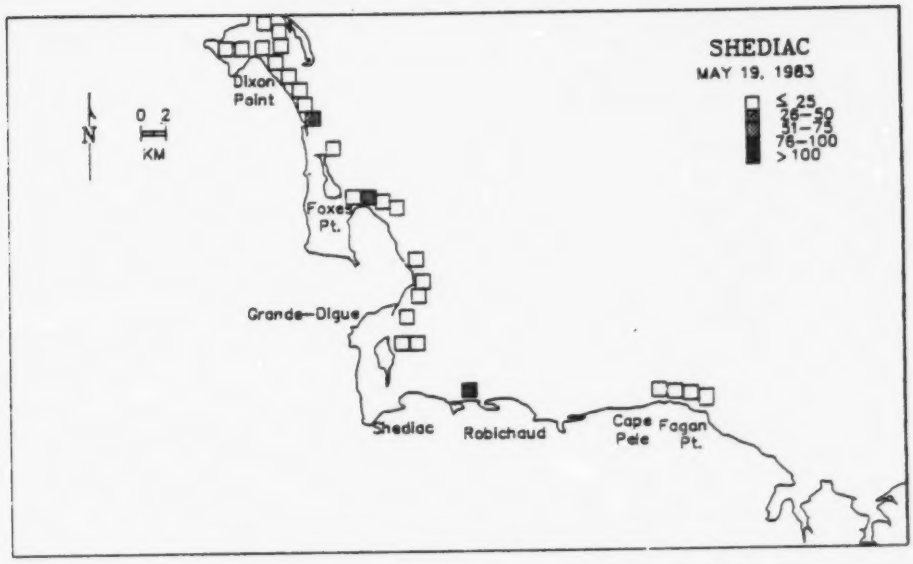
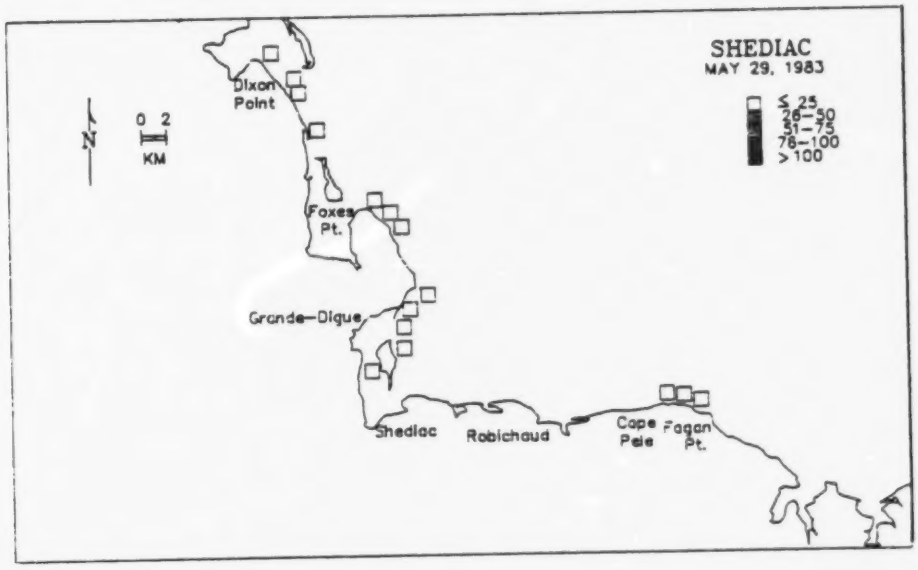
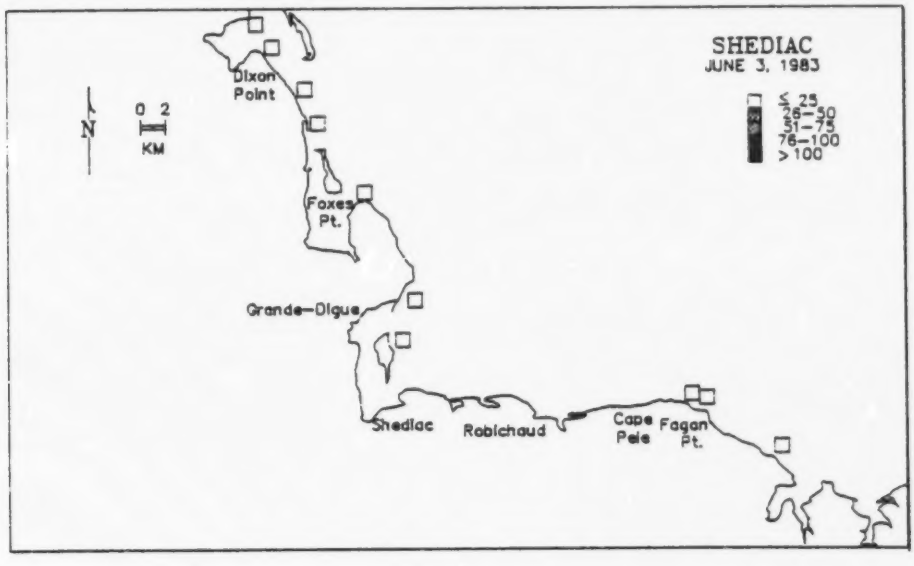


Figure 18. Distribution and density of herring gillnets in the Shediac area, 1983.


SHEDIAC
MAY 19, 1983
≤ 25
26–50
51–75
76–100
> 100
N
0 2
KM
Dixon Point
Foxes Pt.
Grande–Digue
Shediac
Robichaud
Cape Pele
Fagan Pt.


SHEDIAC
MAY 29, 1983
≤ 25
26–50
51–75
76–100
> 100
N
0 2
KM
Dixon Point
Foxes Pt.
Grande–Digue
Shediac
Robichaud
Cape Pele
Fagan Pt.


SHEDIAC
JUNE 3, 1983
≤ 25
26–50
51–75
76–100
> 100
N
0 2
KM
Dixon Point
Foxes Pt.
Grande–Digue
Shediac
Robichaud
Cape Pele
Fagan Pt.

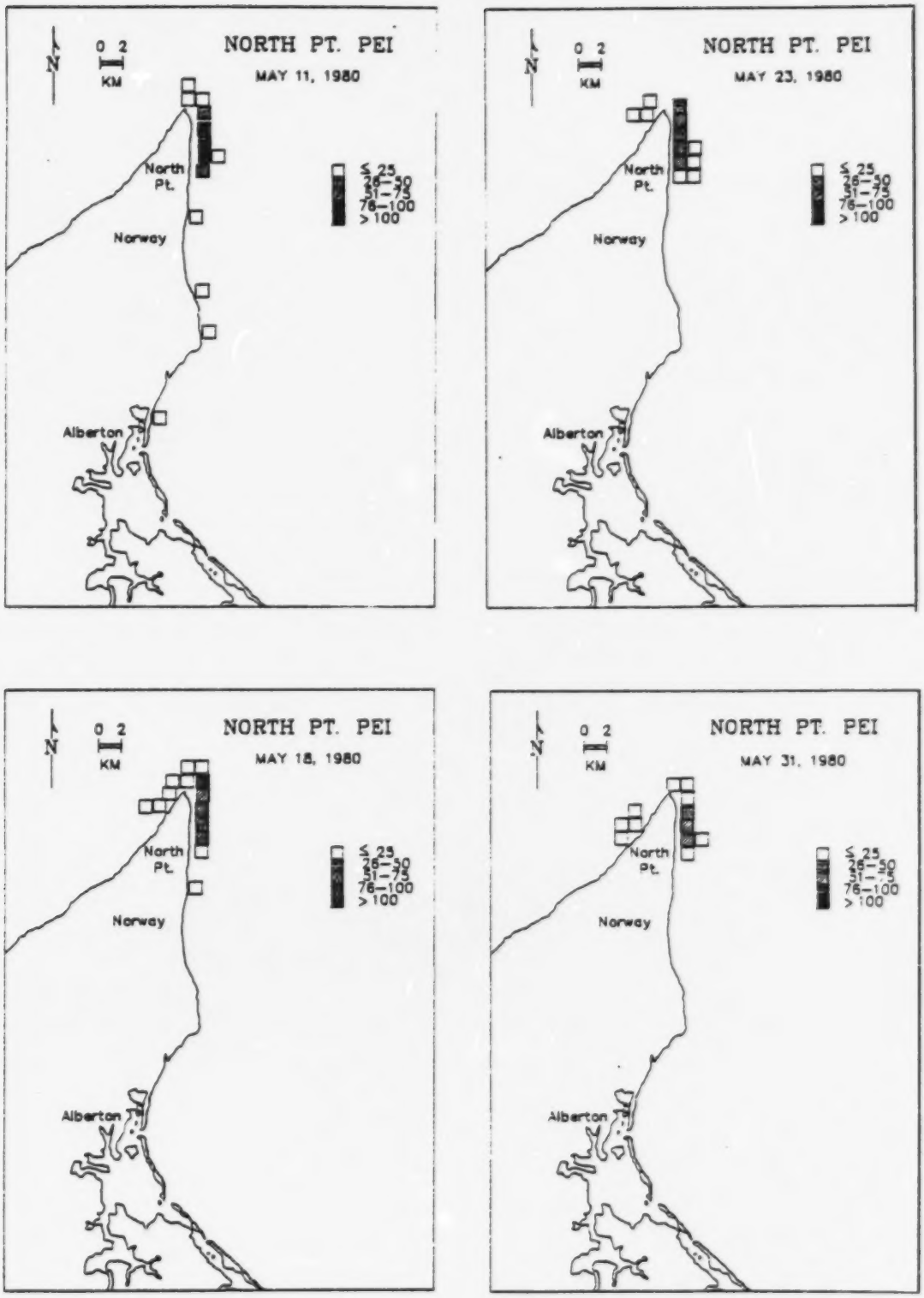


Figure 19. Distribution and density of herring gillnets in northern PEI, 1980.

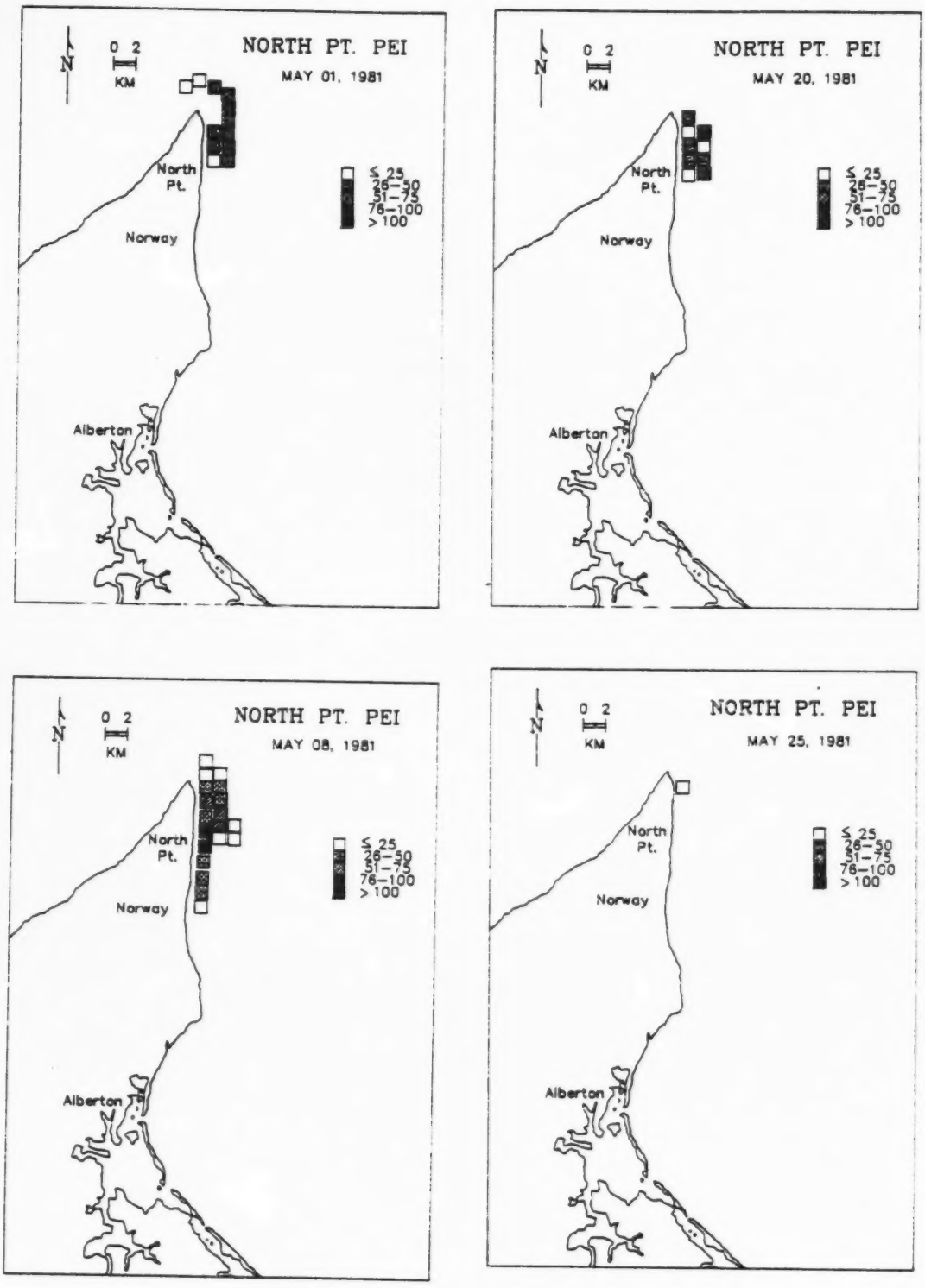


Figure 20. Distribution and density of herring gillnets in northern PEI, 1981.

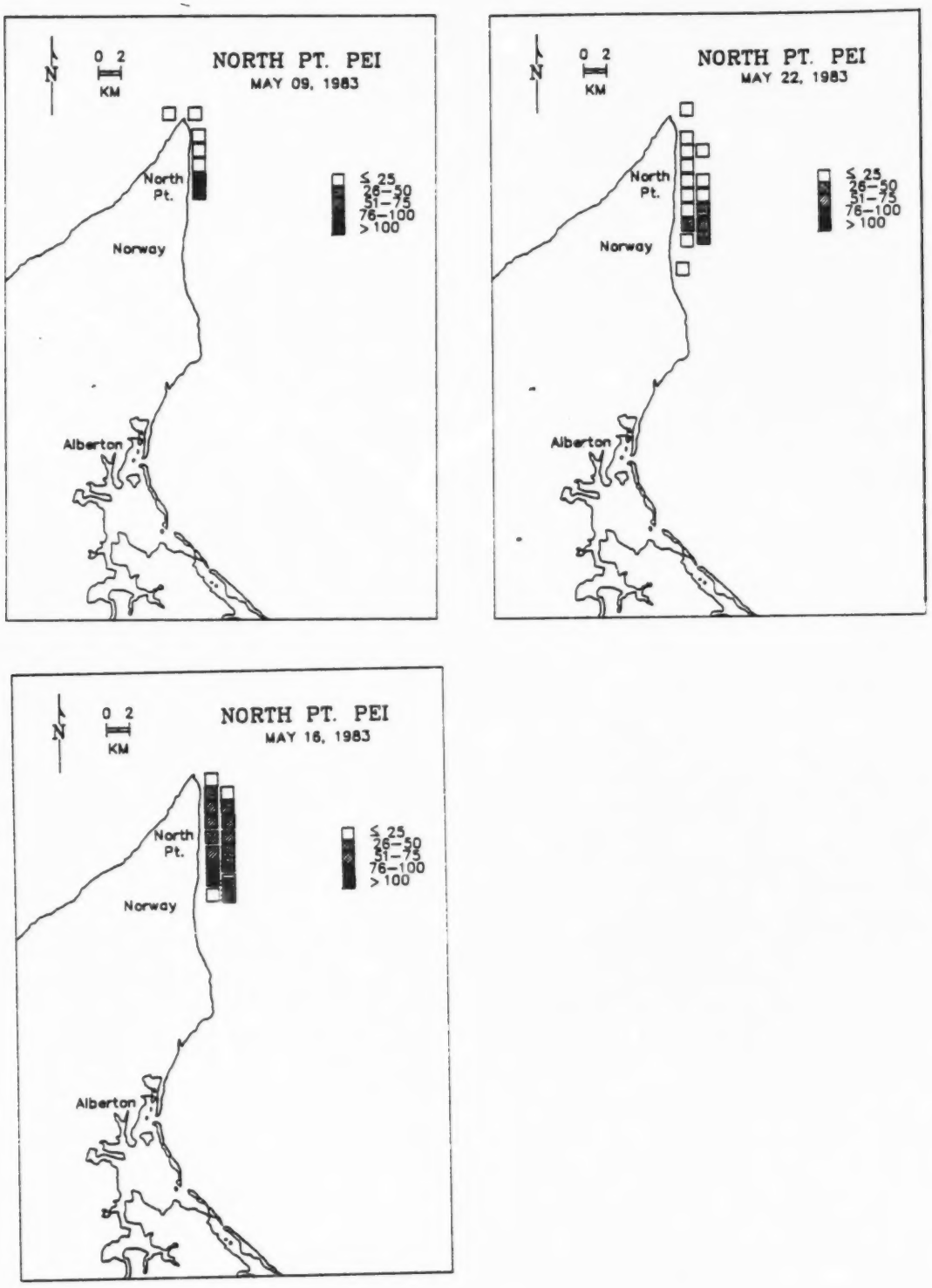


Figure 21. Distribution and density of herring gillnets in northern PEI, 1983.

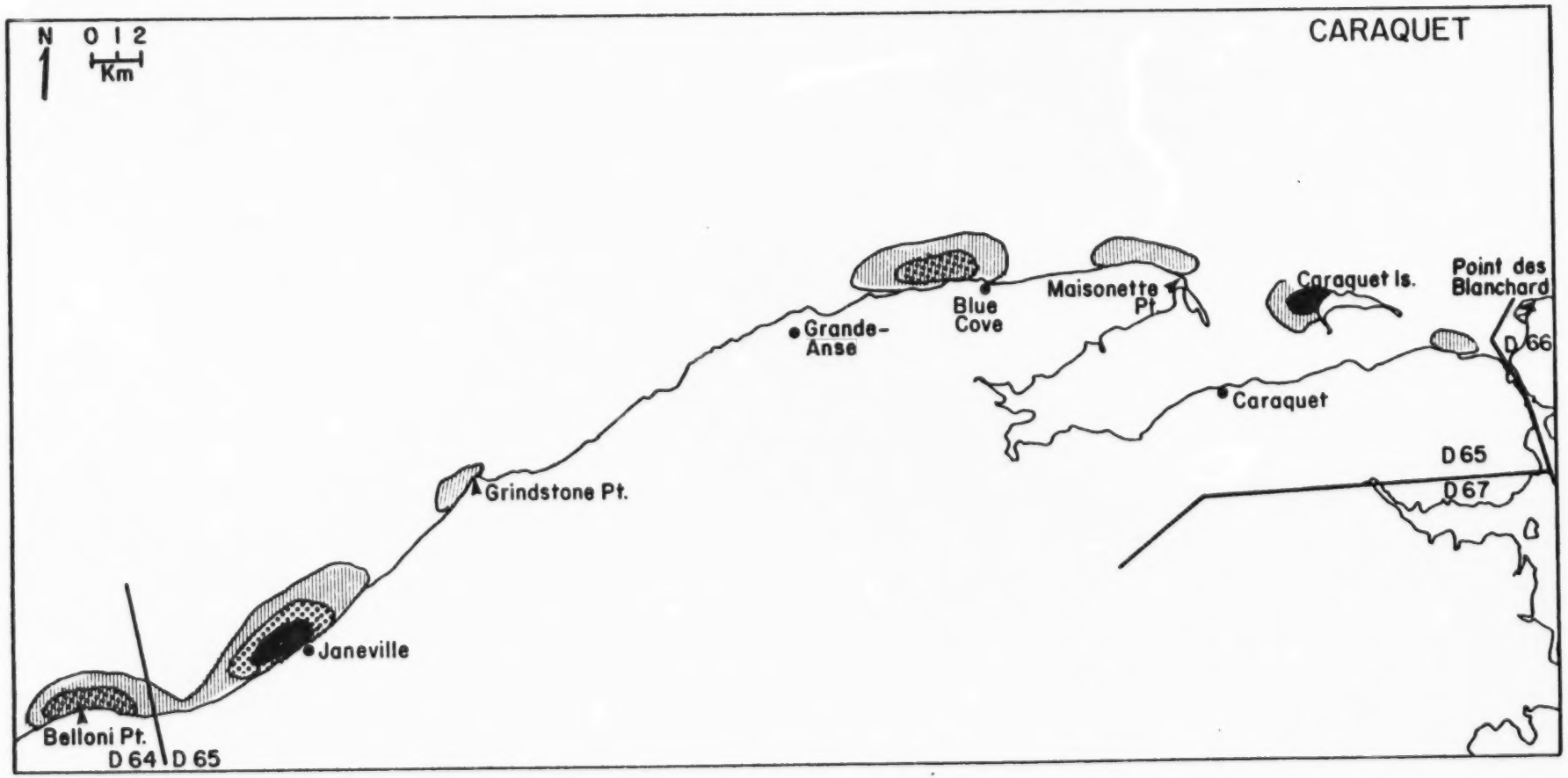


Figure 22. Herring spawning grounds along the northeast coast of New Brunswick (Dist. 64 and 68), and intensity of algal cover.

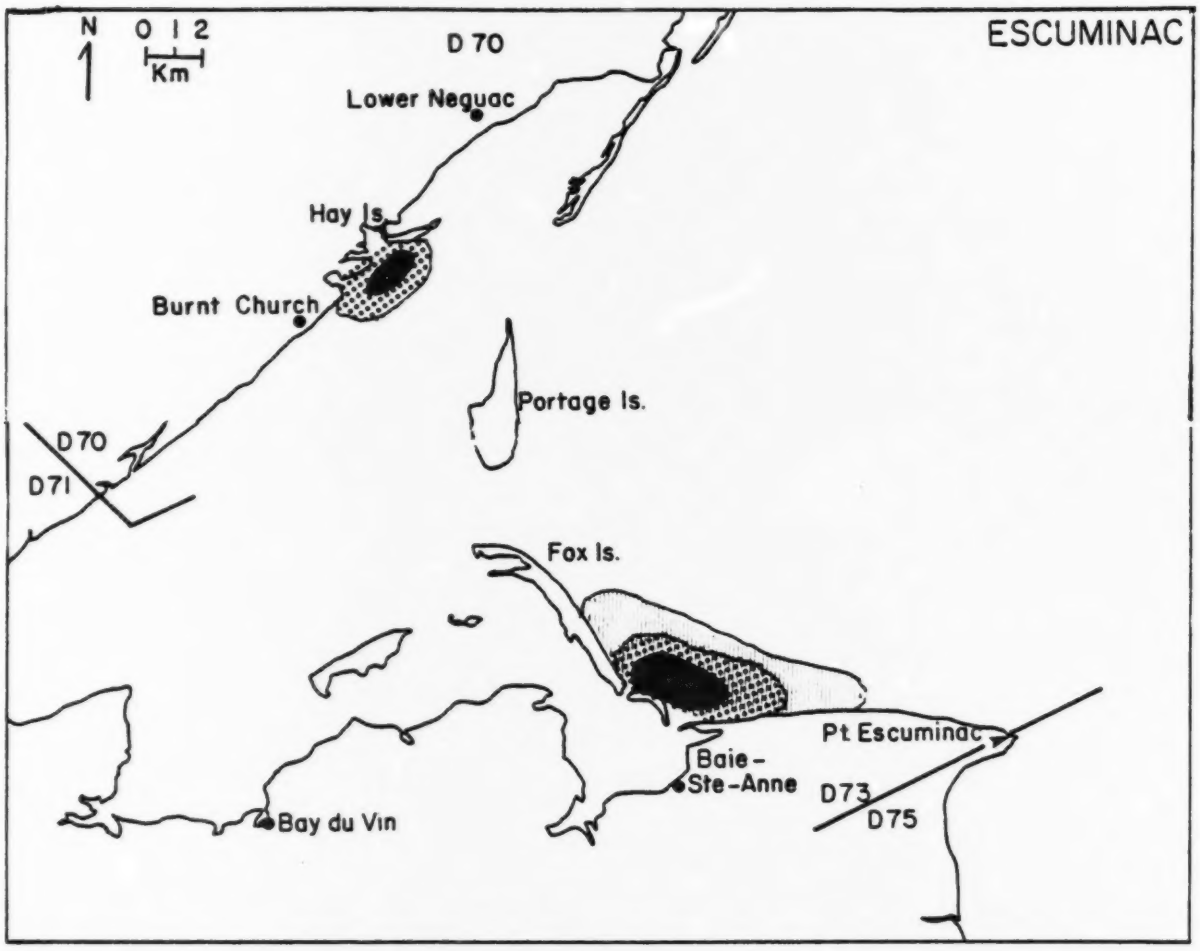


Figure 23. Herring spawning grounds in the Escuminac area (Dist. 73) and the Neguac area (Dist. 70), and intensity of algal cover.

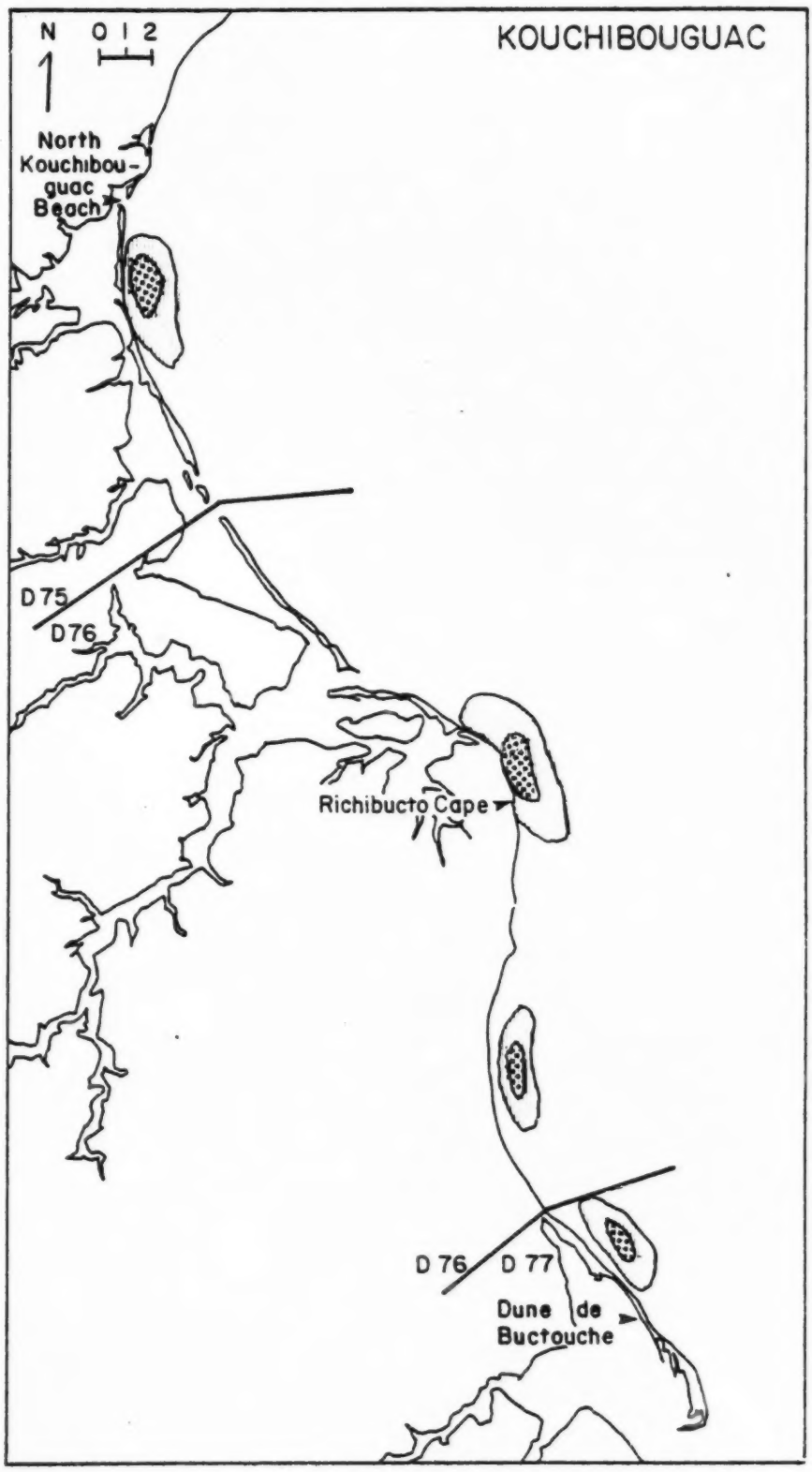


Figure 24. Herring spawning grounds along the eastern coast of New Brunswick (Dist. 75 and 76), and intensity of algal cover.

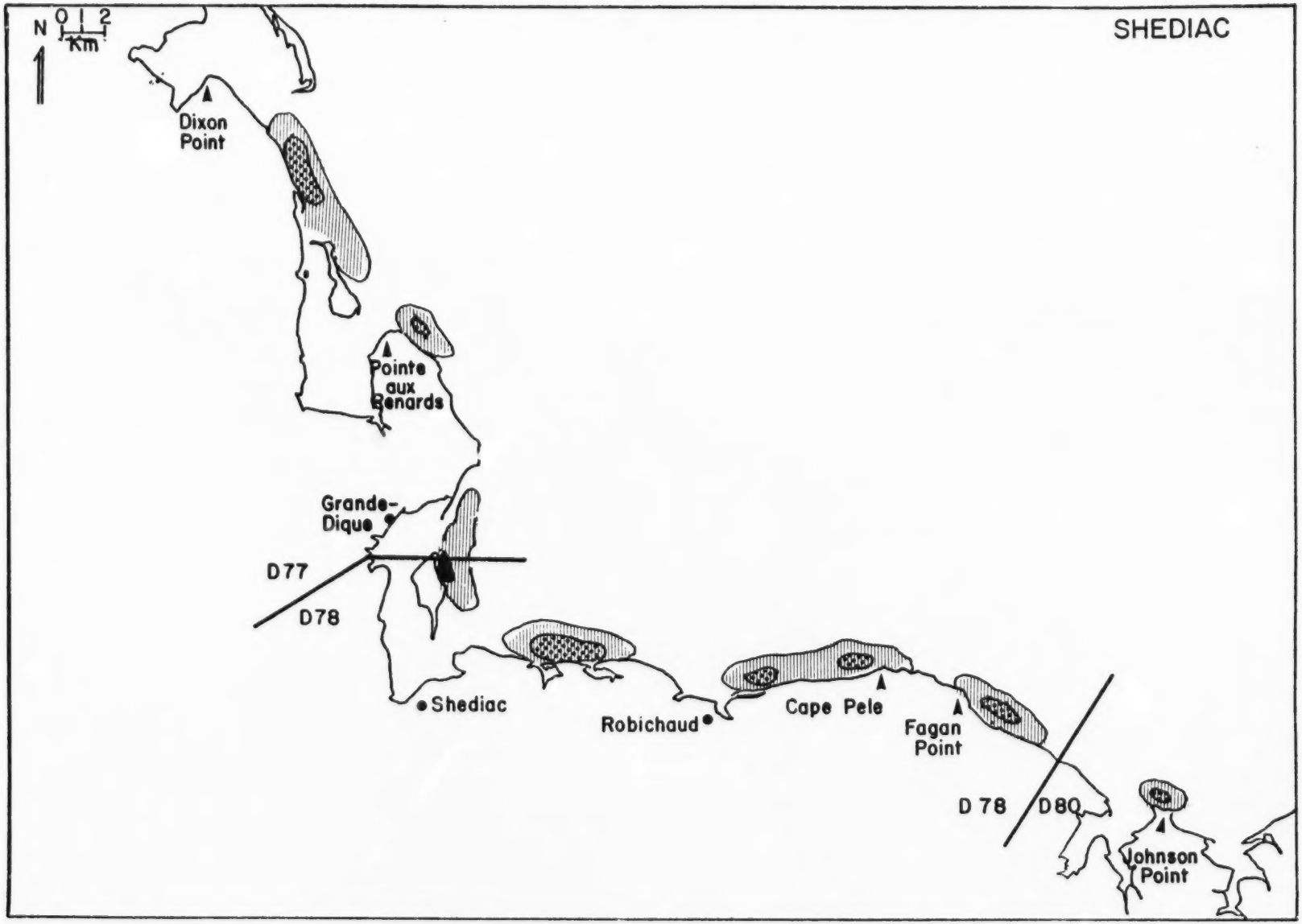


Figure 25. Herring spawning grounds along the eastern coast of New Brunswick (Dist. 77 and 78), and intensity of algal cover.

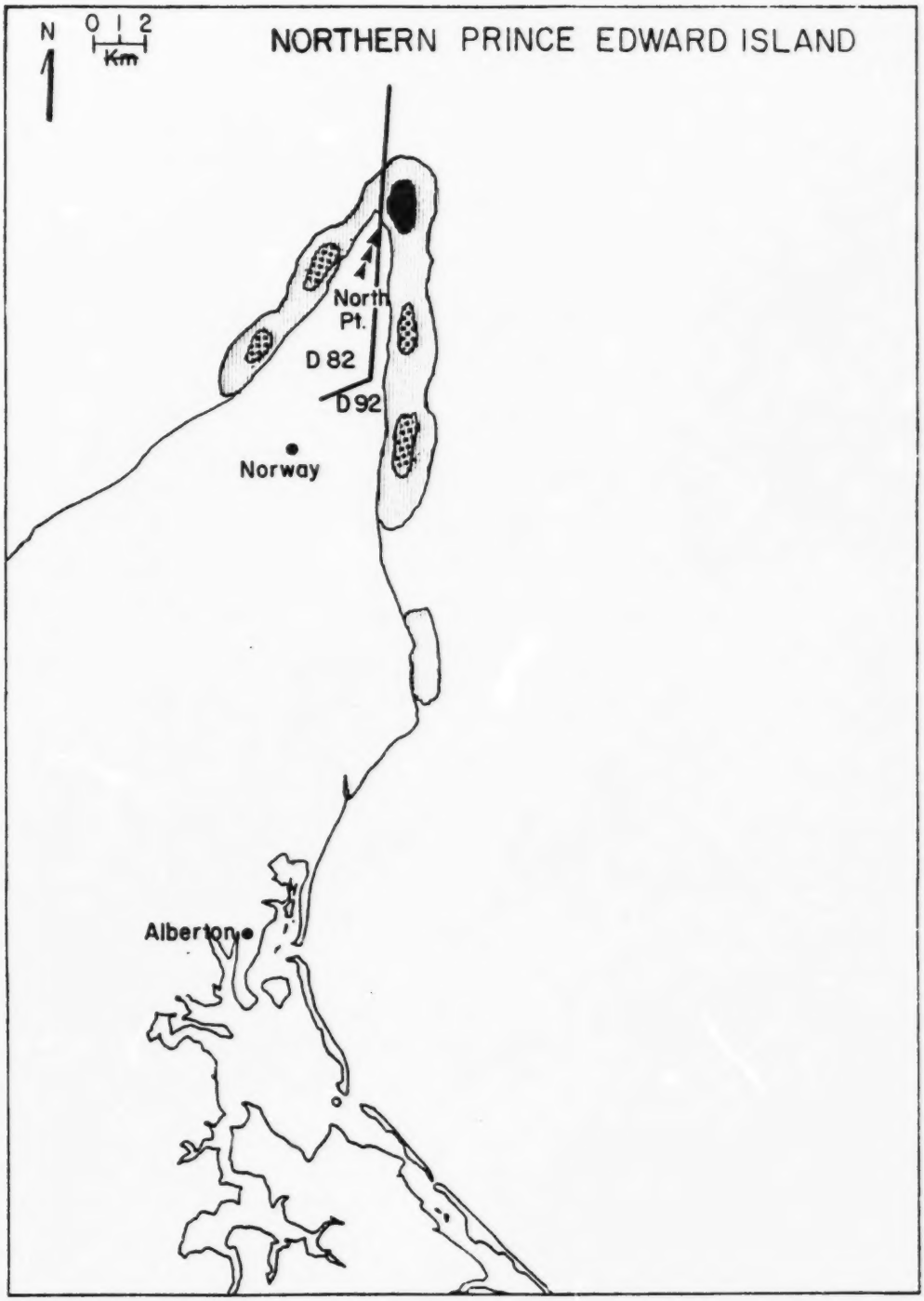


Figure 26. Herring spawning grounds around North Point, Prince Edward Island (Dist. 82 and 92) and intensity of algal cover.